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# AGRICULTURAL ENGINEERING

JANUARY · 1947

Means for Shifting the Center of Pull of a Tractor *Arthur W. Clyde*

Ag Engineering Phases of Farm Work Simplification *I. D. Mayer*

Basis for Planning Modern Farm Implement House Layouts *G. L. Nelson, W. G. Kaiser*

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Rates of Runoff from Small, Natural Drainage Basins *D. B. Krimgold*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

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Big new sprayers of the multi-nozzle type and mighty Case "LA" tractors are bringing new speed to spraying. With a rig of this type, one man becomes a spray crew capable of covering many trees in a few hours. Such power equipment brings a much-needed answer to the problem of better insect and disease control with fewer man-hours, exemplifies the importance of ample tractor power.

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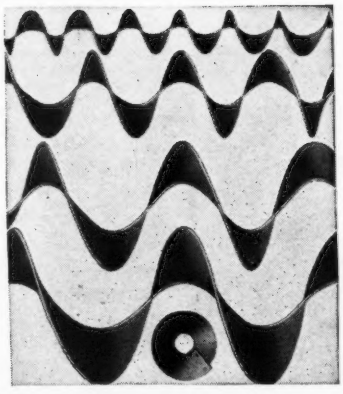
Below: Self-propelled combine cutting and threshing standing grain. Left: With the reel removed, and pickup attachment in use, the same machine is threshing windrowed flax. In this close up, note the two open-end "augers" or screw conveyors, which carry cut grain toward the center feeder elevator.

# LINK-BELT *Screw Conveyor*

## "ASSURES EVEN, POSITIVE MOVEMENT--"



Right: These views are typical of the wide variety in diameters, pitches and gauges of screw conveyor, in both continuous-flight and sectional-flight types as manufactured by Link-Belt for incorporating in agricultural implements.

● Simpler construction and more efficient operation are advantages secured by utilizing Link-Belt screw conveyor on the front end of this combine.

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# AGRICULTURAL ENGINEERING

*Established 1920*

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Chicago, 2: DWIGHT H. EARLY
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RAYMOND OLNEY
*Editor and Business Manager*

# EDITORIAL

## Applied Technical Progress

WE were interested to learn recently that two building material dealers, who have been following A.S.A.E. meetings for a couple of years, feel that the information has helped materially in doubling their farm business in each of the past two years.

They are agricultural college graduates, alert to opportunities to serve farmers and giving the kind of service Dean Chapman was talking about when he addressed the Society at its annual meeting last June.*

This is concrete evidence of the opportunities existing for alert men in farm communities to help translate technical progress in agricultural engineering into early application on farms, to the advantage of the farmers concerned and to themselves. It is the kind of interpretation which can attract desirable personnel, commercial interest, and public service support for the field.

*"Some Engineering Implications in Agricultural Industries and Services," by Paul W. Chapman, AGRICULTURAL ENGINEERING, August 1946.

## Vigorous Leaders

REFLECTIONS of the vigor of the early leaders of the agricultural engineering profession, the creators of agricultural engineering as a new mutation of applied philosophy, continue to light the path ahead. A number of these grand old men are still actively looking forward, and helping others to look forward, to more extensive, intensive, beneficial applications of engineering in agriculture than they dared to suggest, or hope might be possible, forty or fifty years ago.

We are reminded of this by an article in the current "Country Gentleman", entitled "The Long Look at Mechanization," by Philip S. Rose, charter member and third president of the American Society of Agricultural Engineers and veteran of 46 years of action in and for American agriculture and its associated industries.

From this half-century perspective the mountains and molehills already crossed, and those immediately ahead of agricultural engineers, appear in engineering proportion. Phil Rose is not panicked by the repeated threats of doom thrown at us by those who magnify the problems of each successive "today" without a glance forward or back.

He looks forward to the well-nigh complete mechanization of agriculture, to comparable development in its electrification, structures, use and conservation of soil and water, and utilization of agricultural products, to outstanding progress in this direction within the next ten years.

Problems there are, to be sure. Phil Rose and his contemporary pioneers faced and surmounted problems of prime movers, unchartered paths, "horse baggage," recognition, opportunity to work; of survival through some of the later "witch-burning" days of American agriculture; of laying the foundation for agricultural engineering.

Our problems are those of building on their foundations; of engineering refinement; of utilizing a vastly broadened technology; of broadening and refining it still further; of justifying the confidence in agricultural engineering earned by our earlier leaders; of living up to the opportunities being put before us in requests for recommendations and action; of holding to sound principles through self-discipline in place of the former external restraints; of developing a forward vision with clarity and range matching that of our original leaders; of showing the way to further personal and social realization of the benefits of applied agricultural engineering; of maintaining the vigor to attack our problems with the diligence and persistence shown by our predecessors.

By its very nature, the range of science to be utilized, the world-spanning benefits to be realized, the challenge of its opportunities for original, creative thought, agricultural engineering is a field for vigorous leaders. It will attract them. Therein lies the justification for the faith in its future shown by such men as Phil Rose. Only the individual identities of these future leaders, and their specific contributions, remain to be revealed.

## Possibilities in Atomic Fission

SOONER or later, we have surmised, the Pacific atom clouds were due to cast their shadow over our editorial desk in the form of a question mark as to their significance to agricultural engineers. This expectation has materialized. From a quick glance at our Geiger counter we hazard the following preliminary interpretations.

There appears to be no immediate prospect of agricultural engineers or farmers carrying around atomic power packs along with their pens, pencils, and pocket knives. As and when atomic fission is developed as a source of low-cost power, it seems likely that points of generation will be centralized, transmission to points of use will be electrical, and implications to agricultural engineers will be largely matters of power economics. Before atomic power can materially reduce the cost of electric power, it or some other means must be applied in mining, manufacturing, installation, and maintenance to reduce costs of transmission of power, the present large item.

Still nebulous strategies of atomic defense may inspire, within the next few years, some fantastic schemes for dispersion of people and production facilities, for underground and other protection and for tremendous reserves of agricultural raw materials, among other things. It is easy to see that agricultural engineering must be involved in the associated production, storage and processing problems, along with those of housing, air conditioning, sanitation, water supply and related matters. These both from the standpoints of standing defense measures and plans to carry on with what might be left following an atomic attack. Agricultural engineers may well do some thinking in terms of the potentialities and limitations of farm operations and farm product storage as a few of the considerations on which a sound major strategy must be based.

On the pleasanter side, there are immediate implications in the research techniques made possible by atomic fission and its effects. Fission-irradiated materials are already in use, and this use is increasing, in search for new knowledge of biological processes. Watch for results which may throw new light on our engineering objectives in implementing the farm production and handling of organic materials. Watch also for new materials, devices, and techniques which might prove directly applicable in agricultural engineering research. Artificially radioactive tracer atoms may prove valuable in identifying, tracing, and measuring physical as well as biological forces, motions, and combinations of materials. It is conceivable that they may considerably broaden the field of visual analysis of soil and water relationships, mechanical motions, structural design, and electric effects.

We have probably overlooked many possibilities, but the foregoing appear as some of the immediate implications of atomic fission for agricultural engineers.

IN DOMINICAN REPUBLIC, they call it chambron — this jungle-like growth of tropical cacti and mesquite. It happens that chambron infests many thousands of acres, ideal for producing bananas when tamed.

Various clearing methods have been tried including the use of machetes and grubbing axes. The system pictured seems to function particularly well for Grenada Co.

This planter hitches two "Caterpillar" Diesel D7 Tractors to a 300-foot length of properly-swiveled, heavily-weighted 1½-inch cable. Then the two D7s operating 100 feet, or so, apart, take through the chambron at first speed.

The heavy cable in its U-shaped loop flattens the jungle like a giant roller. The D7s then turn and double back over the flattened growth — after which it's ready to bulldoze into piles for burning. Clearing averages about 12 acres in 8 hours. The job of converting the acreage into a thriving banana plantation is simple, with this power, from there!

This same method is being used with success in Southwest Texas!

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AGRICULTURAL ENGINEERING

VOL. 28 JANUARY, 1947 NO. 1

# Shifting the Center of Pull of a Tractor

By Arthur W. Clyde

FELLOW A.S.A.E.

WIDE-TREAD tractors often give trouble in steering control when pulling a plow which is considerably narrower than the tractor. The situation is bad enough with a two-bottom plow and a wide tractor but may be even worse with a one-bottom plow. In either case the interference with steering is most serious when the drawbar pull is near the tractor's capacity. The basic trouble is that the drawbar pull may be applied to one side of the center of pull, this being done to secure a workable hitch point for the plow. This condition is commonly called side draft, but that word is so indefinite that it should be given a more exact name — for example, an offset pull. Moving the drivewheels closer together is sometimes a solution. This, however, is not convenient on some tractors, and on side hills a wide tread is needed for safety against side tipping.

Another difficulty in plowing with a rubber-tired tractor is that sometimes the left wheel may have much poorer traction than the right wheel. A succulent crop growth or dewy grass may so reduce the traction for the left wheel that plowing is hardly possible unless a chain or an unusual amount of weight is added to that wheel. It should be noted that weight is much less effective in securing traction on a slippery surface than on one which is not slippery.

These two difficulties have prompted a study of what might be done to reduce them. This discussion applies to wheel tractors with two rear drivewheels and the ordinary differential. Unless otherwise specified, wheel will refer to a drivewheel and the drivewheels will be assumed to have the same diameter. Much of the discussion applies also to track-type tractors with the steering differential, provided the steering feature is inactive.

*Dynamics of the Center of Pull.* The center of pull of a tractor is usually considered to be midway between the points of contact of the wheels with the ground. This is based on the idea that each wheel is contributing equally to the drawbar pull. If each wheel is contributing equal amounts, *N* and *M* in Fig. 1(a), an offset pull, *P*, tends to rotate the tractor about a vertical axis. It can maintain its position only if the soil supplies side forces *SF* and *SR* to the front and rear wheels. If, however, the right wheel can furnish more than half the pull, Fig. 1(b), the pull can be offset enough to require no side forces.

The idea that each wheel contributes equally is usually based on two assumptions:

1 That the differential divides the applied torque equally between the wheels

2 That the wheels have equal rolling resistance.

The first assumption can be true only if the differential has no friction. This is not reasonable to expect since plain bearings are commonly used for the pinions and side gears. If one wheel is rotating slower than the other, friction in the differential causes the slower wheel to get more than half of the torque. In other words, the differential is not a true equalizer

This paper was prepared expressly for AGRICULTURAL ENGINEERING. Authorized for publication on November 21, 1946, as paper No. 1349 in the Journal Series of the Pennsylvania Agricultural Experiment Station.

A. W. CLYDE is professor of agricultural engineering, Pennsylvania State College.

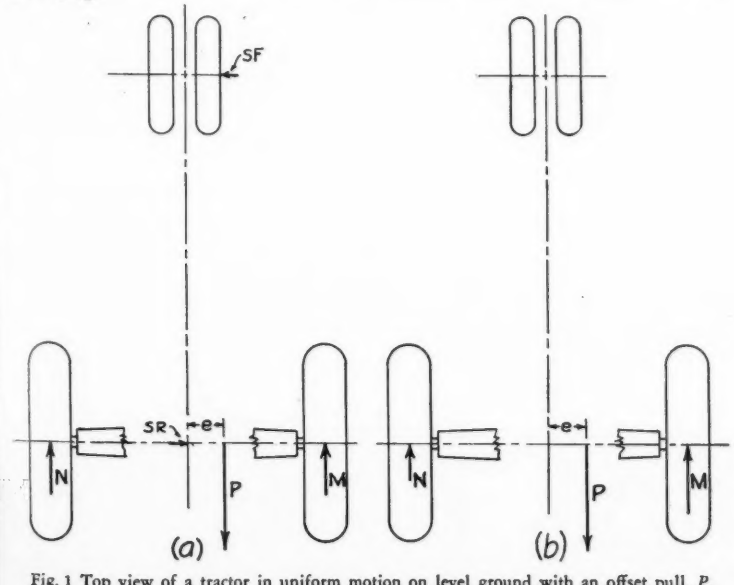



Fig. 1 Top view of a tractor in uniform motion on level ground with an offset pull, *P*. *N* and *M* are the net forward soil forces on the drivewheels after rolling resistance has been subtracted from the total forward soil forces

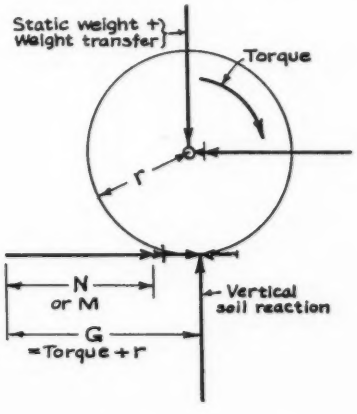



Fig. 2 Forces on a drivewheel in uniform motion on level ground. Vertical forces shown reduced to about one-half their value. Forces acting toward the rear at the axle are those due to part of the drawbar pull and approximately one-half of the front wheel's rolling resistance. Force acting to the rear at the ground line is the rolling resistance of this wheel. *N* (or *M*) is the same as in Fig. 1

if one wheel is rotating slower than the other. With wheels of equal size, more torque goes to the one which is slipping the least.

The second assumption, equal rolling resistance, may not always be true. Force relations in the wheel are shown in Fig. 2. Here the wheel is considered as a free body with the forces and torque which the axle, the soil, and gravity exert on it. If the torque is divided by the radius, *r*, the thrust at the rim is obtained. The thrust is numerically equal to *G*, the total forward soil reaction. This thrust balances the rolling resistance of that wheel plus approximately one-half of the front wheel rolling resistance. Any excess, *N* (or *M*) balances that wheel's share of the drawbar pull, *P*. It is obvious that, if the same torque is applied to two wheels of the same diameter, the wheel with the least rolling resistance can contribute more to the drawbar pull. Thus, either increased torque on the right wheel or decreased rolling resistance may be responsible for *M* being greater than *N* in Fig. 1(b). In this case the center of pull has been shifted to the right of the midpoint. It is similar to having a big horse on the right with a little horse on the left, with the hitch point on the doubletree moved closer to the big horse.

*Non-Stall or High-Traction Differentials.* Many styles of these have been devised and used to some extent in trucks. Their purpose is to prevent the vehicle from being stuck because one wheel has poor traction. Most, if not all, make use of friction. They permit one wheel to run faster than the other, but they then deliver most of the torque to the slow-moving wheel. The Timken-Detroit differential, which was used in one model of tractor before the war, uses a different principle. In it the teeth of the pinions and side gears have a peculiar shape. With a pinion of odd-numbered teeth, the result is a greater lever arm to one side gear than to the other when the pinion is in a certain position. The lever arms may reverse or may be equal, this depending on what position the pinion happens to be in at that instant. It seems possible that this might be valuable in getting through a place where one wheel has poor traction. The operator has no control of it, however.

*An Unequal Torque Differential.* Some time ago D. C. Sprague and the author decided that there might be possibilities in a differential which would, when desired, put more than one-half of the torque continuously to the right wheel. No known type of high traction device does this. This wheel would be weighted more than the other and would be expected to pull more than one-half the load. This would move the center of pull of the tractor toward that wheel. It could be arranged with a regular differential so that the operator could shift quickly from one to the other. One form of such a device is shown in Fig. 3. It was built into a one-fourth size model tractor and tested by having the model drag a weight over the floor. Its performance was such that it was decided to try the idea in a full-size tractor.

A patent search disclosed three patents as follows:

No. 1,235,249, Salfisberg, July 31, 1917, describes an unequal torque differential.

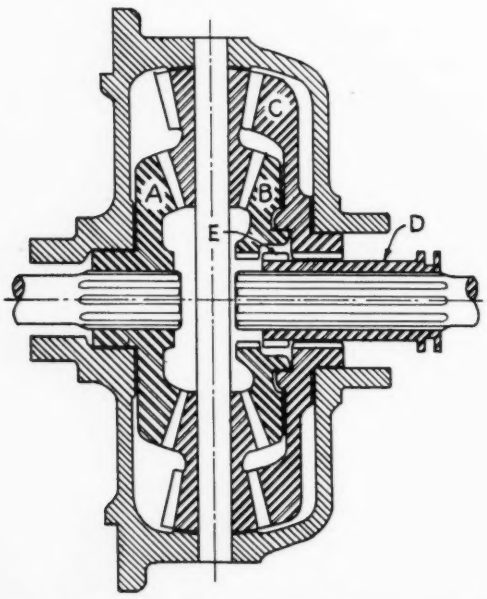
No. 1,247,494, Berquist, Nov. 20, 1917, covers an unequal torque differential combined with an ordinary one with provision for shifting from one to the other (similar to Fig. 3).

No. 1,399,045, Bernstein, Dec. 6, 1921, describes an unequal torque differential.

It is believed that these patents were issued when other problems were much more important, and probably the device was never tested in a full-size tractor. The author has not found anyone in the tractor industry who ever heard of the patents. They have now expired.

To test the idea of unequal torque, C. E. Frudden, executive engineer, Allis-Chalmers Mfg. Co., arranged with the Clark Equipment Co. to furnish the gears for a differential which could be put into an Allis-Chalmers "Model C" tractor. Other parts were made by us and the unit put into one of our tractors. To permit its use in a stock axle, only the unequal feature was built into it. The unit is shown in Fig. 4. Neglecting friction, the theoretical distribution of torque is as follows:

$$\text{To right wheel, } \frac{18}{18+14} \times 100 = 56\tfrac{1}{4} \text{ per cent}$$



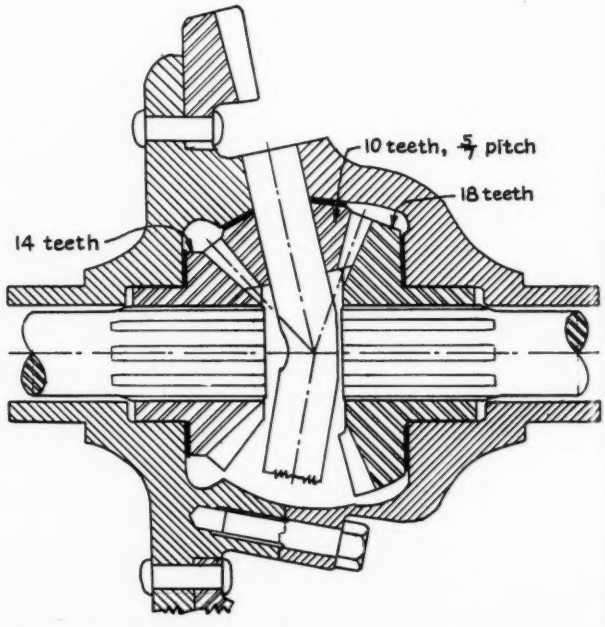




Fig. 3 *(Left)* One form of two-torque differential (not to exact scale). D is a sleeve splined to the axle shaft. It may be moved to the left to engage splines E with gear B for a conventional arrangement. Engaging splines E with gear C gives more torque to C than to A because of C's greater radius • Fig. 4 *(Right)* The unequal torque differential, tests of which are described in this paper

To left wheel, $\frac{14}{18+14} \times 100 = 43\frac{3}{4}$ per cent.

These proportions were merely a guess as to what might be better in plowing, yet still not interfere much with a centrally hitched load.

With a tractor tread of 60 in, this would seem to move the center of pull 3¾ in to the right of the center.

*Tests of the Unequal Differential.* For test purposes the tractor was equipped with a swinging drawbar pivoted under the axle, several holes being provided to permit offsetting as desired. In all cases, even with an angled pull in plowing, the offset *e* (Fig. 1) was measured under the axle, not at the stationary drawbar farther back. Counters showing 1/10 revolution were provided for each drivewheel so their relative slip could be observed. Weight on the right wheel was increased approximately in proportion to the expected torque and its inflation increased accordingly.

In pulling an 18-in plow with an offset *e* of 4 in, there was only a little tendency for the front wheels to move to the right. Steering control was easy. No consistent difference in wheel revolutions could be detected. The tractor was then compared with a regular Model C having the same weight on the rear axle. With both tractors the right and left wheel slip was practically the same. The unequal differential permitted 2 in more offset than the regular one for approximately equal steering control.

In the plowing tests, opinions of several people were taken on the steering control. These opinions might be biased, hence a more objective test was needed. This was accomplished by using the tractor on a paved surface with the steering gear disconnected. A bar was projected about 10 ft in front of the tractor so small irregularities could be corrected by pushing or pulling on the bar. A drawbar pull of approximately 1200 lb was used. Hitch points were then tried until one was found that permitted the tractor to follow a straight course with no tendency for the front end to deviate to either side. This gave an unbiased result; if the hitch were not at the right point, the tractor could not be held on a straight course. Offset *e* varied from 2½ to 3½ in, with 3 in as a frequent result. Usually with 2½ to 3 in offset, the right wheel slipped more than the left, and adding 200 lb weight to it had little effect. In one test, however, the left wheel slipped more and the offset was increased to 3½ in.

In the above trials the offset was never quite as large as was expected. Possible explanations of this are that the right wheel, with more weight, probably had a little greater rolling resistance. Also, it usually slipped more, and friction in the differential was then tending to reduce the offset. To get some check on these points, the tractor was then tried with the right wheel on firm soil and the left on very loose soil. Here the offset had to be 5 to 6 in to cause no interference with steering. Probably higher rolling resistance on the left contributed to this. Little or no difference in slip could be detected, but possibly impending motion in the differential may do as much as actual motion in changing the torque distribution.

*Large Right Wheel, Regular Differential.* To study the effects of friction in the differential, a stock model C tractor is now being tested with a 10-24 tire on the right and a 9-24 on the left. So far about 170 lb more weight has been used on the right. The tread of this tractor is 64 in as against 60 in used before.

Tests on a paved surface, with the tractor level and steering gear disconnected, have shown that the load must be offset 9 to 10 in to have the tractor follow a straight course. Here the right wheel was revolving slower than the left. In pulling an 18-in plow 7 to 8 in deep in stubble, an offset *e* of a 6 in caused no interference with steering. Increasing the offset to 8 in gave a slight pull to the right on the front, but this could be handled by a little angling of the front wheels.

Wheels of unequal size have a drawback which some may consider serious. When traveling without load and when pulling a centrally hitched load, the front end of the tractor tends to go to the side with the smaller wheel. More experience and opinions are needed to decide how important this is.

## CONCLUSIONS

The unequal torque differential accomplishes the purpose of shifting the center of pull and thus improves steering control with an offset pull. The amount of shifting, however, may be more or less than that indicated by the gear ratio. It appears that low slip and low rolling resistance on the right cause the shift to be more than expected. The same conditions on the left tend to reduce the shift.

Reduced torque on the left wheel may be expected to reduce its slip, an item of importance when that wheel has poor traction due to a succulent or dew-covered crop growth.

With the amount of inequality in this differential, no bad effects are noticed in ordinary work with a centrally hitched load, and no bad effects in braking. Probably no tractor operator would suspect from its performance in these respects that the tractor was not a stock machine.

A considerable shifting of center of pull can be accomplished by wheels of unequal size on a conventional tractor. In this case it seems that friction in the differential must be a bigger factor than most of us would expect. Plans are now being made to get measurements of how large an item this friction is.

# Electrification through Agricultural Engineering

DOWN Dixie way the Mississippi Power and Light Co. has a 1946 farm program of better methods which particularly appeals to us because it tells farmers clearly and briefly that it has agricultural engineers available to help them in a dozen or more specific ways.

It avoids "talking down" to its farmer customers. In black and white, with brightening touches of green, it calls its agricultural engineers just that. It avoids calling them "experts", "farm electrification specialists", or any other names. It has outlined an agricultural engineering job to be done; hired some agricultural engineers to do it; and expects them to operate and be known as agricultural engineers.

If they should fail to make good for any reason, the resulting publicity might be unfavorable to all agricultural engineers. But if they pursue with reasonable diligence the policies and program outlined by the company, success seems assured.

The policies of promoting efficient use of farm labor, capital, and local resources are along lines long advocated by leading agricultural engineers. Close cooperation with the public agricultural extension services will provide assistance in extension techniques and application data, as well as coordination with other extension activities in the area.

Its specific ways of helping individual farmers are tangible, logical, important, and applied to matters on which most farmers need agricultural engineering help. The agricultural engineers will work with home economists on farm home applications of electric power and equipment.

The program is particularly progressive in that the agricultural engineers will work with farm groups on physical improvement of marketing facilities, and on local processing of farm products, important as adjuncts to farm income and economically sound farm community development.

In effect, the program will introduce more than 31,000 farm customers to agricultural engineers and agricultural engineering as a basic source of help to make their farms better places on which to live and work.

It is a straightforward industrial acceptance and presentation of agricultural engineering as a basic factor in securing the most effective and profitable farm use of the power service it offers.

It will bear watching, not only by other public utilities, but by other industries offering goods and services which can be used to greatest advantage on farms by being engineered into farm operations.

# Ag Engineering Phases of Farm Work Simplification

By I. D. Mayer
MEMBER A.S.A.E.

MUCH has been said during meetings of the American Society of Agricultural Engineers about the great advances in agriculture during the last 50 years and the important part which agricultural engineers have played in these developments. Most of these discussions have stressed the increased production with decreased quantities of labor and with less strenuous efforts on the part of workers. Agricultural engineers have long been developing labor-saving machinery and equipment and have worked on the design and arrangement of farm buildings for doing chore jobs easier and quicker.

We haven't as a group coordinated our efforts upon the operations of the farm as a whole nor even upon the complete detailed study of an enterprise or job. While we have always been interested in the effective utilization of labor and equipment on the farm, agricultural engineers have seldom actually analyzed a farm job into its component parts, its individual motions, and its effects upon the worker, in order to set up improved methods and then test the methods for effectiveness.

Industrial engineers, as you know, have by their time and motion studies, micromotion procedures, and job analyses been of inestimable value to manufacturers. The proceedings of "Job Instruction Training" and "Job Methods Training" have been discussed in our meetings and doubtless some of you have used these techniques on agricultural jobs.

The war demands for increased agricultural production in spite of acute shortages of farm labor and farm machinery directed the spotlight upon the opportunities for increasing the output per worker and per machine by systematically analyzing each operation of the worker and then trying to improve the procedures. The interest in the opportunities along this line was probably most concretely manifested by the grant by the General Education Board of $87,400 for the organization and carrying out of research in "Farm Work Simplification" in cooperation with 12 land-grant colleges during 1943-44.

During the past year, while on a special assignment on farm labor utilization with USDA Extension Service, I had the privilege during my travels of visiting ten of the twelve states in which these studies were conducted, and I had the opportunity of discussing the work with nearly all of the project leaders. Usable data and educational materials from these projects were made available to us and to other states as quickly as they could be prepared. The materials from this research were widely distributed and were of valuable assistance in carrying on our educational programs to stimulate the use of labor-saving equipment and methods to obtain maximum agricultural production.

You are undoubtedly more or less familiar with this research in farm work simplification carried out under this grant, and under the direction of Dr. E. C. Young, dean of the graduate school of Purdue University, but a brief review of these projects may be in order to serve as a background for the discussions to follow.

The work was apparently well received by the selected institutions because, in addition to the $87,400 furnished by the General Education Board, the state colleges supplied funds totalling $124,320 during 1943-44, and since 1944 the research has continued under state support only. Some colleges have expanded their research, and several experiment stations not in the General Education Board program have started research projects. Several state agricultural extension departments have prepared extension materials from the research findings and have taken these to the farmers.

The 12 states doing the work under the General Education Board program, and the subjects of this research, are as follows:

| State | Commodities studied |
|---|---|
| Colorado | Onions, potatoes, sugar beets |
| Florida | Beans, celery, potatoes, tomatoes, also land clearing |
| Illinois | Beef cattle, sweet corn |
| Indiana | Hogs, poultry, tomatoes |
| Kentucky | Tobacco |
| Minnesota | Dairy |
| Nebraska | Hay |
| New Jersey | Potatoes, poultry |
| New York | Apples, beans, corn silage, dairy, hay, potatoes, poultry, tomatoes |
| Oregon | Beans, potatoes |
| Vermont | Dairy, corn silage, hay |
| Washington | Apples, barn arrangement |
| Massachusetts* | Celery, lettuce, tomatoes |
| New Hampshire* | Dairy |

*Have done work without General Education Board support.

It will be noted that most of the projects were with farm operations which were relatively high consumers of hand labor. Preliminary surveys indicated that there were by and large, less opportunities to effect savings in labor in the production of grains and field crops because of the advances already made by mechanization.

A few examples of savings in labor effected by improved methods worked out by these projects may be of interest.

In a Vermont dairy of 22 cows, a daily saving of 125 min and 10,655 ft of travel was effected.

In a Minnesota dairy farm with 13 milking cows and 14 other cattle, the daily savings were 53 min of labor and 3,107 ft of travel.

In hog production studies in Indiana, savings by improved methods reduced labor requirements by one-fourth to one-half.

Hay harvesting studies in New York showed ranges in man-hours per ton for different methods of from 1.5 to 3.8; opportunities to cut labor in half were indicated.

In tobacco production studies in Kentucky the suggested revised methods increased output per worker 20 to 40 per cent in cutting and spearing and 15 per cent for work in the storage and stripping. Use of special electric lights made continuous work in grading and sorting possible, where the job was formerly dependent upon sunshine and where work had to be stopped on dark cloudy days.

In Florida, studies on celery production, harvesting, and packing, improved methods increased production per worker approximately 40 per cent. Since these studies were made, a celery harvesting machine has been developed which will reduce labor requirements still more.

In Colorado, the quantity of potatoes harvested per worker was increased 20 to 30 per cent by improved methods and equipment.

In order to carry on this research it was necessary to train workers, to provide materials and equipment for obtaining the information, and to analyze the data and to report the results. These functions were carried out by the National Laboratory through schools, conferences, and personal supervision in the field.

In most of the colleges the project leaders had the advice and counsel of an advisory com- *(Continued on page 17)*

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at St. Louis, Mo., June, 1946.

I. D. MAYER is associate in agricultural engineering, Purdue University Agricultural Experiment Station.

# A Basis for Planning Farm Implement House Layouts

By G. L. Nelson and W. G. Kaiser
JUNIOR MEMBER A.S.A.E. FELLOW A.S.A.E.

FARM machinery storage has become a most urgent farm building need that can be expected to grow as a flood of tractors and other equipment becomes available. Many farms have become so mechanized that tractor-powered machinery has completely replaced horse-drawn machinery; while other farms are becoming more and more extensively equipped with tractors and allied equipment. The Doane Agricultural Digest for November, 1946, reports that, if the increase in farm tractors continues at the 1940 to 1945 rate, the number will climb from 2,072,000 in 1945 to 2,600,000 in 1950, and may possibly exceed 3,000,000. Because investment in tractors and tractor-powered machinery is high, owners feel that the risk of outdoor storage is too great for sound management and therefore desire to build farm implement houses. It is likely that these owners will build regardless of whether or not the economic returns from the building fully justify the expenditure.

What constitutes a functionally adequate farm implement house for modern power machinery? Those who contemplate implement house construction will expect the answer from farm building specialists in colleges and industrial organizations. Building standards for sheds to house horse-drawn machinery are hardly applicable to implement houses for modern machinery. The building layout brings new aspects into the planning problem — essentially one of planning for sufficient sheltered space arranged to allow convenient storage, servicing, and repair of the machinery. Special emphasis is placed on convenience. Unless the building is arranged to promote easy entrance and exit of the machinery and to favor "good housekeeping" in repair and servicing operations, the purpose of the implement house is likely to be defeated. Operators hesitate to place machinery in storage if time will be lost reshuffling implements or in extricating the desired machine from space not easily accessible. This is borne out by the tendency, noted on farms where the storage facilities are not well planned, to keep much-used machines outdoors past the operating season, while the little-used implements are protected in the machine shed.

If convenient storage is to be a primary objective in planning, the plan must provide the correct doorway heights and widths as well as specific floor space for each machine. Since there is considerable variation from farm to farm in the types and amount of equipment, each farm will require an especially planned layout of the implement house.

Planning on an individual farm basis is not difficult when information on the storage space requirements of each machine

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

G. L. NELSON and W. G. KAISER are, respectively senior agricultural engineer and manager, farm bureau, Portland Cement Association.

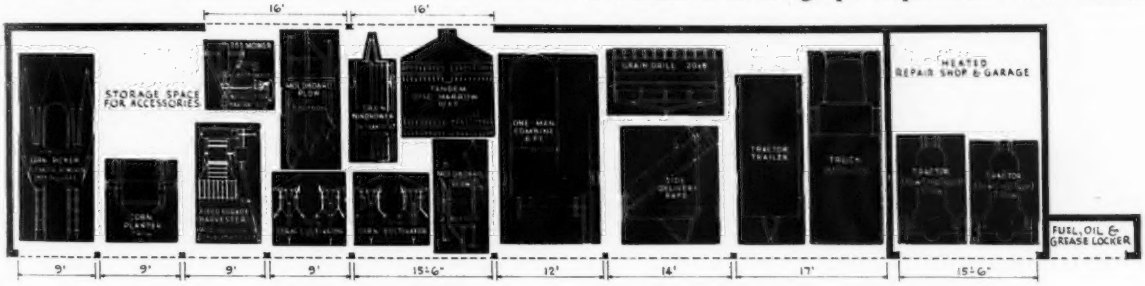



Fig. 1 This diagram illustrates how an implement house can be planned to provide specific space for each machine. The machinery arrangement used in planning the layout is to be followed when the machinery is actually placed in storage

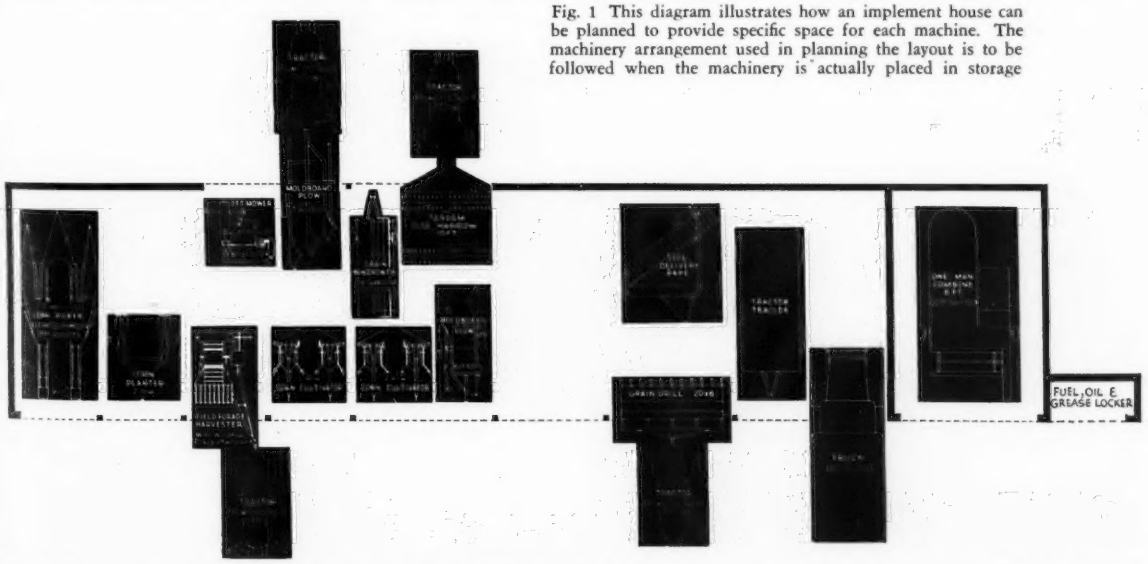



Fig. 2 Doorways are arranged and proportioned to allow removal or entry of each machine without moving other machinery. The shop doorway accommodates even the largest machine — in this case, a combine

to be housed is at hand. Measurements of the actual machinery on the farm desirable for planning, since dimensions of a given type of machine vary slightly for different manufacturers. Table 1 has been developed for circumstances where on-the-farm measurements are not readily available, as when planning for future needs. These data are based on information furnished by a number of leading farm implement manufacturers. The lengths, widths, and required door heights are shown to the nearest one-half foot over the size determined from the manufacturers' information.

Figs. 1 and 2 show implement size data have been applied to lay out an implement house for the machinery represented by rectangular cards scaled to the length and width of the machine to be housed. Instead of containing a sketch, each card can be labelled and marked with the required door height and an arrow to show direction of travel. An assumption for the implement house width must precede trial arrangements of the cards. An outside width of 26 ft generally provides efficient use of storage space for a single row of long implements or a double row of shorter implements. The width might be increased to allow storage in three rows; but such an arrangement makes removal of machinery from the center row difficult, and will likely result in poor utilization of space.

After the width has been established and laid out to scale, various arrangements of the cards are tried until an arrangement is obtained which will expedite entry or removal of each machine and make economical use of space. From the standpoint of convenience alone, the best layout would provide continuous doorways on three or four sides of the implement house. However, every plan will be modified by need for structural soundness, need for weathertight construction, and the location of the implement house with respect to the other buildings. The final arrangement of the cards will show the required over-all building length, doorway sizes, and doorway spacings. One section may be provided with doorways on both sides to allow easy entry or removal of demountable machinery stored in a double row. Variation in doorway width is advisable to eliminate unnecessary maneuvering around door posts without sacrificing usable space. An implement house with doorways all of one size is as impractical from a functional standpoint as a barn or hog house with doorways of only one size.

In addition to specific floor space for storage of each machine, a complete layout usually requires a combination repair shop and garage with floor space and doorway size to accommodate the largest machines. A firesafe fuel, oil, and grease storage locker can be conveniently incorporated in the plan near the section of the implement house where the tractors are housed and serviced.

A paved floor is desirable for several reasons. Tractor-mounted implements require stable footing in storage to prevent misalignment when the machine is remounted on the tractor. Heavy machines are rolled into an allotted space on a

Fig. 3 Implement house with continuous doorways to machinery storage space. Heated shop and garage occupy opposite ends of building

TABLE 1. STORAGE SPACE REQUIREMENTS FOR TRACTOR-POWERED FARM MACHINERY. (REQUIRED DOORWAY HEIGHTS BELOW 8 FT ARE NOT LISTED. WHENEVER POSSIBLE, USE MEASUREMENTS OF THE ACTUAL MACHINERY ON THE FARM FOR PLANNING PURPOSES)

| Machine and Nominal Size | Length, ft | Width, ft | Required doorway height, ft |
|---|---|---|---|
| *Tractors* | | | |
| Row-crop type, 1-plow | 10½ | 7 | |
| 2-plow | 11½ | 7½ | |
| 3-plow | 12 | 7½ | |
| General-purpose type, 2-plow | 10 | 5½ | |
| 3-plow | 10½ | 6 | |
| 4-plow | 11 | 6 | |
| *Tillage Machinery* | | | |
| Moldboard plow, 2-bottom | 12½ | 6 | |
| 3-bottom | 15 | 6½ | |
| 4-bottom | 16½ | 7½ | |
| Disk plow, 2-bottom | 11½ | 6½ | |
| 3-bottom | 15 | 8 | |
| 4-bottom | 17 | 10 | |
| Disk harrow, single, 15-ft | 5½ | 9 | |
| (with end sections 18-ft | 6 | 10 | |
| folded) 21-ft | 6 | 12 | |
| Disk harrow, tandem 7-ft | 10½ | 7 | |
| 8-ft | 11 | 8 | |
| 9-ft | 11 | 9 | |
| 10-ft | 11½ | 10 | |
| Lister, 2-row | 9½ | 8½ | |
| 4-row | 11 | 16 | |
| Corn cultivator, 2-row | 8 | 8 | |
| 4-row | 8½ | 12 | |
| Field cultivator | 10½ | 15 | |
| Rod weeder | 12 | 15 | |
| Rotary hoe | 7 | 7½ | |
| *Planting and Seeding Machinery* | | | |
| Grain drill, 12x6 | 7 | 8 | |
| 20x6 | 7 | 13 | |
| 28x6 | 9 | 16 | |
| 18x7 | 9 | 12½ | |
| 24x7 press drill | 10 | 15½ | |
| 16x10 press drill | 8½ | 15 | |
| Corn planter, 2-row | 9 | 8 | |
| 4-row | 12 | 14 | |
| Potato planter, 1-row | 7 | 4 | |
| 2-row | 11 | 6½ | |
| *Harvesting Machinery* | | | |
| Grain binder, 10-ft | 19 | 11 | 9 |
| 8-ft | 17 | 11 | 9 |
| *Grain windrower, 6-ft | 12 | 5 | |
| 8-ft | 14 | 5 | |
| 12-ft | 17½ | 7½ | |
| Combine, one-man, 5-ft cut | 19 | 10 | 10 |
| 6-ft cut | 21 | 11 | 10 |
| 8-ft cut | 24 | 11 | 11 |
| 12-ft cut (with platform removed) | 24 | 12 | 13 |
| Combine, two-man, 14-ft cut (with header removed) | 22½ | 11 | 13 |
| Combine, self-propelled, 9-ft cut | 18 | 10 | 12 |
| 12-ft cut | 23½ | 13½ | 13½ |
| 14-ft cut | 21 | 15½ | 13 |
| Threshing machine, 22-in cylinder | 26 | 7½ | 12 |
| 28-in cylinder | 26 | 8 | 12 |
| Corn binder, 1-row | 14 | 8½ | |
| 2-row | 14 | 13½ | |
| Ensilage harvester, 1-row | 13 | 7 | |
| Ensilage cutter and blower | 12 | 5½ | |
| Corn picker, drawn, 1-row | 15 | 9½ | 8½ |
| 2-row | 15 | 11½ | 8½ |
| Corn picker, mounted, 2-row (with elevator removed) | 20½ | 8½ | 8 |
| Corn sheller | 20 | 5½ | 11 |
| Potato digger, 1-row | 17 | 5 | |
| 2-row | 18 | 8½ | |
| Field forage harvester—hay, grass silage and corn silage (with delivery spout removed) | 13½ | 7½ | |
| *Haying Machinery* | | | |
| Mower, 6-ft | 7½ | 6½ | |
| 7-ft | 7½ | 7½ | 8½ |
| Side-delivery rake | 13 | 11 | |
| Hay loader | 13 | 8 | 10 |
| Field hay chopper | 20 | 9 | 9 |
| Pickup baler | 17 | 13 | 8 |
| *Hauling Machinery* | | | |
| Manure spreader | 15½ | 6 | |
| Tractor trailer | 18 | 7 | |
| Truck, 1½-ton | 21 | 8 | 8 |
| Farm wagon | 15 | 6 | |
| Lime spreader, 8-ft | 4 | 10½ | |

*In transport position with A frame and outside divider removed.

hard-surfaced floor with greater ease and convenience than on softer, uneven fill of earth or gravel. A paved floor also helps in maintaining an orderly shop.

The method suggested above for preparing implement house layouts precludes use of stock plans showing fixed building lengths and door arrangements. However, a plan which shows a basic layout extendable to meet individual needs will be a valuable guide. Many structural details are independent of the machine-shed layout and can be shown on the basic plan. Design data for various doorway widths can be provided by a table which lists respective lintel sizes for any desired range of doorway sizes.

Planning for actual needs will usually result in a building somewhat larger than anticipated. However, the reduction of building size below that required is false economy. If storage space is cramped, the usefulness of the implement house will be seriously impaired. In budgeting for a modern implement house it seems justifiable to invest in a larger building for tractors and power machinery than for horse-drawn machinery. On farms operated solely with tractor power, construction for horse stalls and storage of horse feed, hay, bedding, and harness is not required. The saving occasioned when the need for horse shelter and feed storage is eliminated could be applied to construction of larger, more adequate implement houses for tractors and equipment. It is conservatively estimated that the floor space for eight horses and the feed necessary to maintain them for 75 working days plus 75 days of indoor maintenance per year is equivalent to that in an implement house 26 ft wide and 40 ft long.

## Farm Work Simplification

*(Continued from page 14)*

mittee which usually included representatives of all subject matter departments which might have an interest in the project. Agricultural engineering was represented on most of the committees. However, only *one* project had an agricultural engineer for its leader. But during the progress of the research, agricultural engineers were frequently called upon to design, construct, or operate equipment or to plan or rearrange farm buildings. In most of the projects engineering problems arose and either active engineering assistance was provided or some phases of the project were not carried to completion.

Most of the projects reported savings of labor by simplifying the job. Agricultural engineers should, however, look further than just to simplifying the job; they should also develop superior methods and processes and design more efficient buildings and equipment.

The use of electrical energy for speeding up the job or for lightening the labor used under present methods or for the development of new processes or procedures afford many opportunities for research for the rural electrification group.

Farm structures engineers should study all farm building designs critically from the standpoint of the best possible utilization of the labor necessary to carry out the various activities involved in the use of the buildings. This should include studies of the locations and interrelations of the several buildings in the farmstead.

The engineers in the soil and water group should study means for improving the drainage and irrigation practices so that the control of the water and the cropping of the soil can be done with greatest possible labor efficiency. Soil conservation practices and the control and effective use of farm waters require critical analyses if the labor involved is to be used to best advantage.

The members of the farm power and machinery group have always considered labor utilization in the design of farm machines, but changing cropping methods, new varieties, plant diseases, insects and industrial use of products continually challenge their machinery designs.

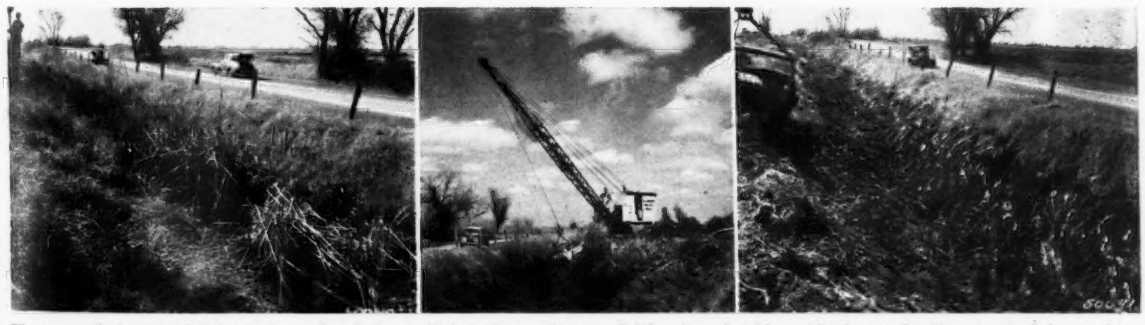
Farm processing, the handling of crops and livestock, and the providing of a good farm living with the labor available on the farm provide serious problems for all of us to work upon. The engineering phases of the study of efficient utilization of farm labor are vast and open a large field for agricultural engineering research.

The principles of farm work simplification have apparently received wide acceptance among professional agricultural workers and farmers. The opportunities for improvement in the utilization of labor and equipment on the farm and in the farm home seem almost limitless. The possibilities for lightening the work and for bettering the working conditions should afford a challenge to all agricultural engineers. *It is essentially an engineering job.*

If research in farm work simplification is to be expanded, many additional workers must be trained in the methods and techniques found most effective in obtaining the data. Then this information must be interpreted and put into language the farmer can understand and translated into practices the farmer can follow. Full cooperation of the research and extension workers will be essential for this phase of the work.

College and high school teachers will probably need refresher courses before they feel capable of presenting the research findings to their students.

The General Education Board by its grant of funds to stimulate production as a war effort started an organized study of the problem. The projects have trained a few workers and have produced some methods, techniques and equipment for further research. They have produced some teaching materials used to instruct farmers in solving their problems. This program has in reality been a reconnaissance survey and has only opened a large field which needs further investigation. It is essentially an engineering and management field in agriculture. That's agricultural engineering. I know that many of you have been thinking and studying about this. What shall we *do* about it?



These are "before" and "after" views of a drainage ditch in Sutter County, Calif., cleaned with a Northwest dragline powered by a Caterpillar diesel engine

# Drainage Surveys in the Texas Gulf Coast Area

By Roy L. Hauger
MEMBER A.S.A.E.

SINCE early 1942, seven soil conservation districts totaling 4,919,000 acres have been created along the Texas Gulf Coast. These districts were formed because the landowners in that area realized their need for assistance in drainage and in soil conservation and improvement. The districts include Victoria, Calhoun, Matagorda, Fort Bend, Brazoria, Galveston, Chambers, Liberty, and Jefferson Counties.

The first activity of a newly created soil conservation district is the preparation of a district program, describing in considerable detail the agricultural conditions and problems of the district. This is followed by the development of a district work plan which describes the course of action the district proposes to follow in solving its agricultural problems.

When the supervisors of these seven soil conservation districts undertook to prepare programs and work plans, they soon found that they needed a great deal more information than was available on drainage conditions and needs before they would be able to decide upon a course of action. Consequently they asked the Soil Conservation Service to assist them by making drainage surveys in these districts.

So that the field survey work might be completed before July 1, 1946, a nine-man survey was organized last February in each of the districts. A survey party consists of an engineer as party chief and two four-man crews of engineering aids. The party and crew chiefs are experienced Soil Conservation Service engineers and aids detailed for the period of this survey. The crews were completed by hiring veterans locally, many of whom had some previous survey experience.

The objectives of the preliminary drainage engineering surveys are to determine (1) the condition of natural or artificial drainageways and their capacity, (2) the needed improvements of the existing drainage system, (3) the additional facilities needed to provide adequate drainage, and (4) the estimated costs and benefits of the drainage system.

All maps, surveys, records, engineering and soils data available that had been previously collected by every federal, state and local agency and individual were assembled for each district. Aerial photographs and U. S. Corps of Engineers quadrangle sheets were used as base maps. U. S. Coast and Geodetic Surveys, Corps of Engineers, Texas State Reclamation Department and State Highway Department bench marks were used for vertical control. A bench mark map of each district was also developed. All known drainageways were located and identified on base maps by name and number.

The field procedure used was to run lines of differential levels across each drainage problem area at approximately two-mile intervals along easily identified lines such as roads, railroads, fences, etc. Each line was called a transect line and identified by a capital letter on the district map. Level readings were taken on natural ground surfaces between turns not exceeding 1500 ft. Cross sections were taken on all natural and artificial drainageways and temporary bench marks were set at main ditches and streams and at one-mile intervals. All physical features influencing drainage improvements such as bridges, culverts, pipelines, and flumes were noted and their condition was indicated. Watershed lines usually were located by inspection, using surveys where necessary. Drainageways were walked out to determine roughness coefficients, alignment, high water marks, type and amount of clearing needed, and to obtain intermediate cross sections at approximately one-mile intervals.

Distances were determined by stadia. Stadia boards were used in differential leveling, with an allowable error of plus or minus one-tenth foot times the square root of the distance in miles. Survey parties have completed surveys in approximately 50 per cent of the area of each district.

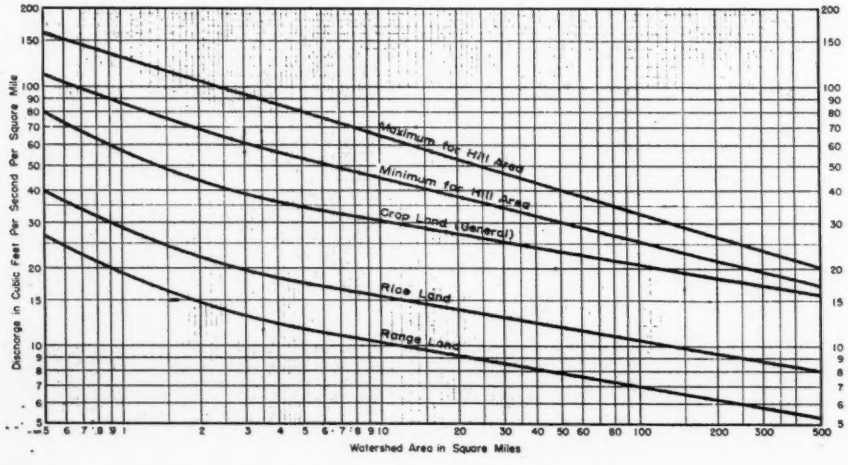
Plans, profiles and cross sections of all drainageways having more than 2500 acres of watershed will be prepared. Hydraulic gradients will be superimposed on profiles and their slope calculated. The design of each drainageway will be based on the drainage runoff curves for the Texas Gulf Coast, which are based on drainage requirements for various land uses such as cultivation, pasture or rice. The maximum runoff curve for hill area is based on the formula $Q = 130M^{0.7}$, in which $Q$ = discharge in cubic feet per second and $M$ = drainage area in square miles. The minimum runoff curve is based on the formula $Q = 80M^{0.75}$.

The cropland runoff curve is based on the formula $Q = 45M^{5/6}$ for areas exceeding five square miles. From 0.5 square mile to 5 square miles the curve has been turned up to provide greater rates of removal from the smaller drainage areas. The rice land runoff curve was determined by taking one-half the values of the cropland runoff curve, and the range land runoff curve was determined by taking one-third the values of the cropland runoff curve.

The capacities of all drainage ditches will be determined by the Manning formula and the designed cross sections superimposed on original cross sections to determine yardage. All structures will be studied and needed improvements designed. The amount of right of way needed *(Continued on page 21)*

This paper was presented at a meeting of the Southwest Section of the American Society of Agricultural Engineers at Fort Worth, Tex., April, 1946.

ROY L. HAUGER is district conservationist (Victoria, Tex.), Soil Conservation Service, U. S. Department of Agriculture.


Maximum for Hill Area
Minimum for Hill Area
Crop Land (General)
Rice Land
Range Land
Discharge in Cubic Feet Per Second Per Square Mile
Watershed Area in Square Miles

Drainage runoff curves for the Texas Gulf Coast, from Corpus Christi to Orange

# Transmission Dynamometer for Traction and Power Take-off Power Measurements

By R. J. McCall
MEMBER A.S.A.E.

THE power take-off method of applying power to a mounted or drawn machine has come into general use since 1925. It has been difficult to measure the power required to operate a power-take-off-driven machine under actual field operating conditions.

The transmission dynamometer (Fig. 1) as described was designed and built at the Ohio State University in 1940 and will measure either or both (1) the power required to drive the machine through the power take-off shaft and (2) the drawbar power required to haul the machine through the field.

Equipment of this type is valuable in teaching some phases of the advanced machinery courses, particularly the engineering majors. It serves a need in the research field as a means for determining the power required to operate a machine as affected by various adjustments and conditions.

The general requirements used as a basis for this design and the desired features of the completed unit may be stated as follows:

1 Measurements of power required to operate the machine through the power take-off shaft

2 Measurement of power required to draw the machine through the field

3 Results that will be accurate under adverse conditions such as dust, rough fields and widely variable loads

4 Apparatus simple enough that an inexperienced operator may take the necessary data with little chance of human error entering into the data

5 Sturdy and compact design

6 Adaptability to various machines likely to be tested with a minimum of change-over

7 Conformance, as nearly as possible, to the American Society of Agricultural Engineers' standard for power take-off drives

8 Handle tractors up to and including three-plow size

9 Both power measurements taken simultaneously or individually as desired

10 Protection of the operator from physical injury

11 Provision for a shock absorber so that the data recorded will be usable and not affected too much by shock loads

12 Proper direction of rotation of power take-off shaft (clockwise).

Fig. 1 The transmission dynamometer with the power take-off shaft to the tractor in position. The small cylinder at the end of the box contains oil to replace what little leaks past the pistons. When the valve is released, the oil may be pumped into the system

This paper was prepared expressly for AGRICULTURAL ENGINEERING. and is an abstract of a master's thesis, entitled "The Design and Construction of A Transmission Dynamometer for Traction and Power Take-off Power Measurements", by Robert J. McCall, the Ohio State University, 1941.

R. J. McCall is agricultural engineer, Howard S. Sterner Co.

*Power Take-Off Dynamometer.* The power take-off dynamometer (Fig. 2) consists essentially of a hydraulic cylinder, compression link to the balance arm frame, four roller chain sprockets connected with a roller chain, driving sprocket B and the driven sprocket A. The connecting chain passes over sprocket C. Sprocket D is an idler sprocket and is securely

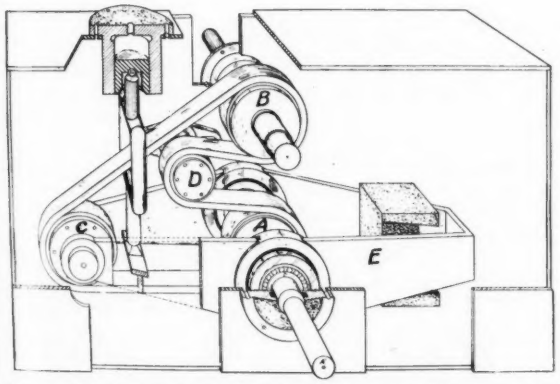



Fig. 2 This drawing shows the main working parts of the power take-off dynamometer. In the actual machines a ¾-in pitch double-width roller chain was used. The recording unit is driven from shaft B. The proper speed reduction was obtained with the single-width roller chain and sprockets. A positive clutch was incorporated in the reduction drive so that the recording unit could be started or stopped at any time

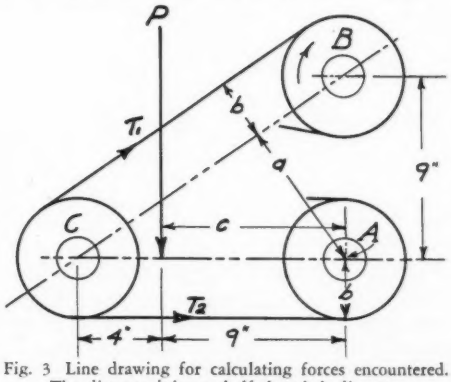



Fig. 3 Line drawing for calculating forces encountered. The distance *b* is one-half the pitch diameter of the sprockets

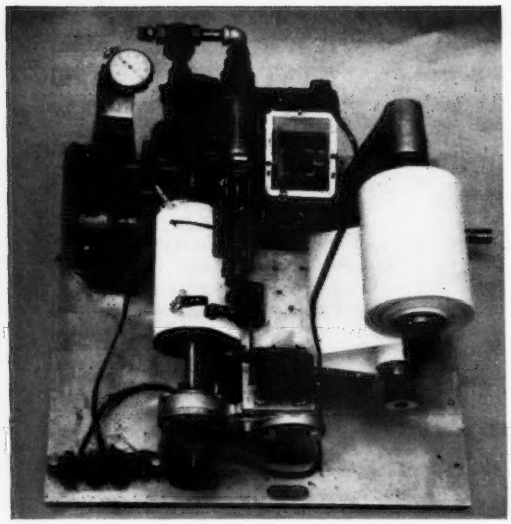


Fig. 4 One of the Gulley recording units used with the dynamometer

fastened to the housing. The idler sprocket shaft may be shifted horizontally, enabling the chain tension to be adjusted. Idler sprocket D also serves to bring more teeth of the sprocket B and A in contact with the chain.

Sprocket C (Fig. 2) is mounted on the balance arm frame which is pivoted at A. The arm also carries the counterbalance weight and connecting link to the piston. The purpose of the counterbalance is to absorb some of the shock load which will reduce the violent fluctuations of the system, also to balance the weight of the chain, sprocket and connecting link.

*Analysis of Forces in Power Take-Off Dynamometer.* Power is received from the motor (or engine) through the shaft B which is connected indirectly by means of a chain to shaft A which transmits the power to the load (Fig. 3). The power take-off shaft of a tractor turns to the right; thus the sprocket B turns clockwise and if a torque is applied to A, there will be a tension $T_1$, $T_2$ in the chain resulting in a torque on the frame E. Rotation of the frame is prevented by the force $P$ supplied by the recording unit.

The chain tension $T_1$, $T_2$ can be calculated since revolutions per minute of the power take-off shaft and the maximum horsepower to be transmitted are known.

Solving the forces by moments is one method that may be used to determine the various forces. If moments are taken about A, then,

$$T_2 b + Pc = T_1 a + T_1 b$$
$$T_2 b + Pc = T_1 (a + b)$$
$$Pc = T_1 a + T_1 b - T_2 b$$
$$Pc = T_1 a + b (T_1 - T_2)$$

Neglecting friction,

$$T_1 = T_2$$
$$Pc = T_1 a + b (o)$$

Therefore,
$$P = \frac{T_1 a}{c}$$

The force $P$ on the connecting link acts against the hydrostatic piston and causes a pressure to be built up in the hydrostatic unit. This pressure is transmitted through an oil line to a Gulley recording unit where it is recorded.

Friction was not considered when making the calculations for the size of the members and the forces in the system. A liberal factor of safety was used in the design and the additional stress caused by friction would not be serious. If the dynamometer is calibrated, friction losses will not affect the final results.

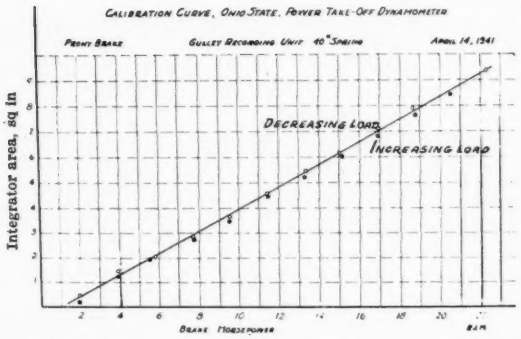



Fig. 5 Calibration curve resulting when integrator area is plotted against the horsepower output. The horsepower was measured with the use of a Prony brake connected directly to the dynamometer with a power take-off shaft. Windage correction for the Prony brake was applied when calculating the horsepower

The Gulley recording unit (Fig. 4) consists of a pressure indicator mechanism, strip chart drive, integrator disk, and a stop watch.

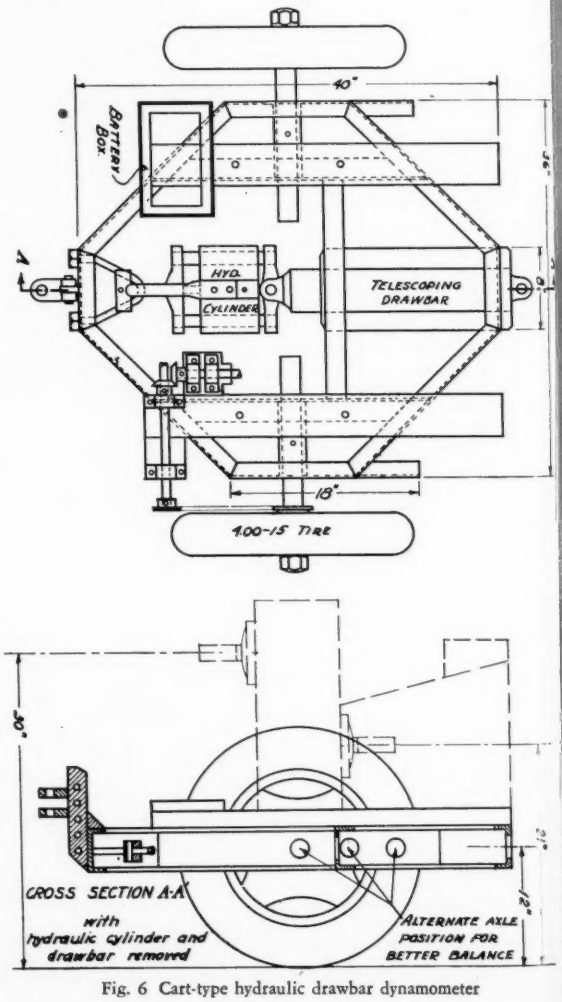



Fig. 6 Cart-type hydraulic drawbar dynamometer

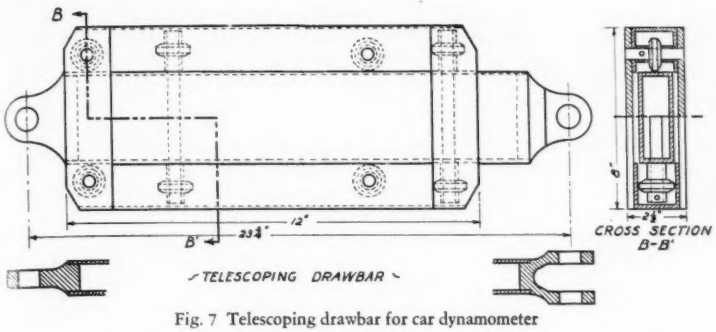



Fig. 7 Telescoping drawbar for car dynamometer

If a force is applied on the piston, there is a definite pressure built up and this is transmitted through the oil line to the pressure indicator mechanism. This force on the head of the indicator piston causes the piston to move outward against the pressure indicator spring. As the indicator spring is compressed, the stylus moves outward on the chart. An automatic integrator device records the area enclosed as the chart moves forward.

The length of paper travel is measured by means of a counter connected to the paper rolls. The gear ratio of the counter is such that the counter records inches and hundredths of an inch of paper travel. The integrator area divided by the recorded length gives the mean average height of the curve traced by the stylus. The mean average height represents a force and is proportional to the torque. By means of proper calibration factors, horsepower may be calculated from the chart records.

The paper travel counter, stop watch, integrator mechanism and the stylus that records the beginning and end of the tests are operated in unison by solenoids controlled by a common switch. The electrical energy is supplied by a six-volt storage battery.

The power take-off unit was calibrated with use of a Prony brake and the area as recorded on the integrator was plotted against the horsepower transmitted. The following formula for a straight line is the result taken from the calibration curve (Fig. 5):

$$HP = \frac{(1.79A + 3.1)}{T}$$

where $HP$ = horsepower output, $A$ = integrator area, and $T$ = time in minutes.

*Cart-Type Hydraulic Drawbar Dynamometer.* The hydrostatic type recording drawbar dynamometer consists essentially of three units: (1) hydraulic pressure cylinder and piston assembly, (2) recording unit, and (3) ground wheel to drive the recording unit.

The design of the power take-off dynamometer is such that a cart is needed to transport the unit. To facilitate compactness of the completed dynamometer the drawbar unit was incorporated as part of the dynamometer carriage. The left wheel of the dynamometer carriage was used as a ground wheel to drive the recording unit for the drawbar dynamometer. The speed ratio is such that one inch of paper travel is equal to 20 ft of ground travel. The front or tractor drawbar connection of the dynamometer is welded to the main frame with provisions for height adjustment of from 10 to 16 in to correspond with the tractor drawbar height (Fig. 6).

The hydrostatic pressure unit has one end fastened to the main frame and the other end fastened to the telescoping drawbar. The telescoping drawbar (Fig. 7) serves two purposes: (1) It acts as a support for the tongue of the drawn machine and (2) it transmits the force required to pull the machine in a straight line through the hydrostatic unit. The telescoping drawbar is equipped with guide rollers to reduce friction to the minimum.

Hydraulic instruments are used to measure the draft. The oil pressure from the dynamometer cylinder is transmitted to a direct-reading draft gage, and the pressure indicator mechanism of the Gulley recording unit (Fig. 4). By changing springs in the pressure indicator mechanism, draft loads up to 8,000 lb may be measured.

The direct reading draft gage is desirable for use with students in the non-technical power courses, since the recording instruments are not easily understood by them.

During the summer of 1940, combine efficiency tests were performed to determine the correlation between the three factors: threshing efficiency, adjustment, and power requirements of the machine. The drawbar dynamometer has also been used in class work to study the power requirements of tillage machinery. Both units have proved very satisfactory.

The completed dynamometer unit weighs 1000 lb without the operator. Although this amount of weight is undesirable from the standpoint of handling the equipment, it is needed to give stability when testing wide machines.

The Ohio State University transmission dynamometer is one design that may be used for determining power requirements of various machines. There are several other possibilities that should be investigated before any one design is considered best for the purpose for which it is intended.

## Drainage Surveys

*(Continued from page 18)*

and the types and amount of clearing will be determined. An estimated cost of drainage improvements by watersheds will be itemized and tabulated.

Reconnaissance conservation surveys have been completed in all districts. These conservation surveys include a map showing the location of all soil groups and land use, and a narrative report describing each soil group, adapted crops, and drainage and conservation needs and limitations. These will supplement the engineering information. An estimate of the benefits of adequate drainage, obtained by evaluating increased crop yields and more intensive use of land or introduction of new crops, will be tabulated and compared to the estimated costs of drainage improvements or rehabilitations.

The supervisors then will have sufficient information to prepare a report to all landowners in the district on the proposed drainage improvements, costs, and benefits. This information will enable landowners to determine whether or not a watershed drainage system can be installed which will be economically justified. It will then be the responsibility of landowners and the soil conservation district to determine the type of organization needed and the methods of financing, construction and maintenance necessary to drain their lands.

Detailed drainage engineering surveys and designs must be made prior to construction.

Soil conservation districts have indicated they will seek the aid of the Corps of Engineers on channel and major drainageway improvements, the state highway department on bridges and culverts, and other federal, state and local agencies. Some districts are planning to create water control and improvement districts, others are planning consolidation or additions to existing drainage districts to fulfill local responsibility and administration needs.

A coordinated soil conservation program, including proper land use, the right combination of conservation practices, improvement of soil productivity and economically sound conservation farming, will be applied and maintained on farms as soon as they have an adequate drainage system.

# Wind Loads on Farm Buildings

By E. G. Molander
MEMBER A.S.A.E.

HEAVY property damage from recent windstorms along the North Atlantic Coast indicates the importance of strengthening farm buildings where it is needed and using materials most effectively.

In this paper three main points are considered: (1) Wind velocity and pressure, (2) distribution of wind forces, and (3) resistance to wind forces, including the stiffening effects of floors and end walls. The attempt is made to provide a guide as to where to look for weaknesses. All the calculations are, of necessity, rough and without any refinements. The importance of rigid floors and walls and the need for special fastening of various members of the building frame are pointed out.

1 *Wind Velocity and Pressure.* Pressure exerted on a building by wind is governed by many factors, such as wind velocity, atmospheric pressure and temperature, height above ground, shape of building, and its orientation towards the air stream.

In this discussion it will be assumed that the velocity pressure $q$, in pounds per square foot equals $0.002558V^2$, where $V$ is true wind speed in miles per hour, the barometric pressure is 29.92 in, and the temperature 59F (degrees Fahrenheit). Based on the foregoing assumption, the following table gives the approximate velocity pressure for various wind speeds:

| | |
|---|---|
| $V = 76$ mph | $q = 15$ lb per sq ft |
| $V = 88$ | $q = 20$ |
| $V = 99$ | $q = 25$ |
| $V = 108$ | $q = 30$ |
| $V = 117$ | $q = 35$ |
| $V = 125$ | $q = 40$ |

H. L. Whittemore, according to unpublished data on strength of low-cost houses of the National Bureau of Standards, worked out velocity pressures that could be anticipated at 30 ft above ground in any locality in the United States. Pressures at 20 ft would be approximately 10 per cent less, and at 40 ft approximately 10 per cent more than at 30 ft. His pressure curves are based on the maximum average wind velocity for a 5-min interval as reported by the U. S. Weather Bureau plus 50 per cent gust. His wind map shows a velocity pressure of from 20 to 40 lb per sq ft along the coastline of the northeastern states (Maine, Vermont, Connecticut, Massachusetts, New Hampshire, Rhode Island, New York, New Jersey, Pennsylvania, Delaware, Maryland and West Virginia) and from 10 to 20 lb for the interior.

On the strength of Whittemore's data it seems reasonable to assume for design purposes a velocity pressure of 30 lb per sq ft for a strip 50 to 100 miles wide along the coast and 15 lb for the interior.

2 *Distribution of Wind Forces.* The external wind forces on building elements vary with their orientation towards the air stream and height above ground. Table 1 shows the average distribution in terms of velocity pressure $q$ on walls, roofs, and eaves.

TABLE 1. AVERAGE DISTRIBUTION IN TERMS OF VELOCITY PRESSURE, $q$, ON WALLS, ROOFS, AND EAVES

| Building element | Orientation | Velocity pressure |
|---|---|---|
| Walls | Windward | 0.80 $q$ pressure |
| " | Leeward | 0.50 $q$ suction |
| " | Parallel | 0.58 $q$ suction |
| Roofs | Windward— | |
| " | 0 to 20 deg slope | 0.77 $q$ suction |
| " | 20 to 30 deg " | 0.77 $q$ to zero suction |
| " | 30 to 60 deg " | 0 to 0.58 $q$ pressure |
| " | 60 deg and over | 0.58 $q$ pressure |
| Roofs | Leeward, flat | 0.77 $q$ suction |
| " | " sloped | 0.58 $q$ " |
| Roofs | Parallel, any slope | 0.77 $q$ " |
| Eaves | Maximum pressure up | 1.57 $q$ |
| " | " " down | 1.16 $q$ |

The wind forces shown in Table 1 are based on a windtight building. Loads from internal wind forces must be added for buildings with openings or potential openings such as windows or doors. For buildings having 30 per cent or more wall openings in windward side add 0.77 $q$ pressure out on roof and walls, and for openings in leeward or parallel sides add 0.58 $q$ suction in. For openings between 0 and 30 per cent of wall area, assume proportional additional loads.

This paper was presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers at Fairlee, Vermont, September, 1946.

E. G. MOLANDER is senior agricultural engineer, division of farm buildings and rural housing (BPISAE), U. S. Department of Agriculture.

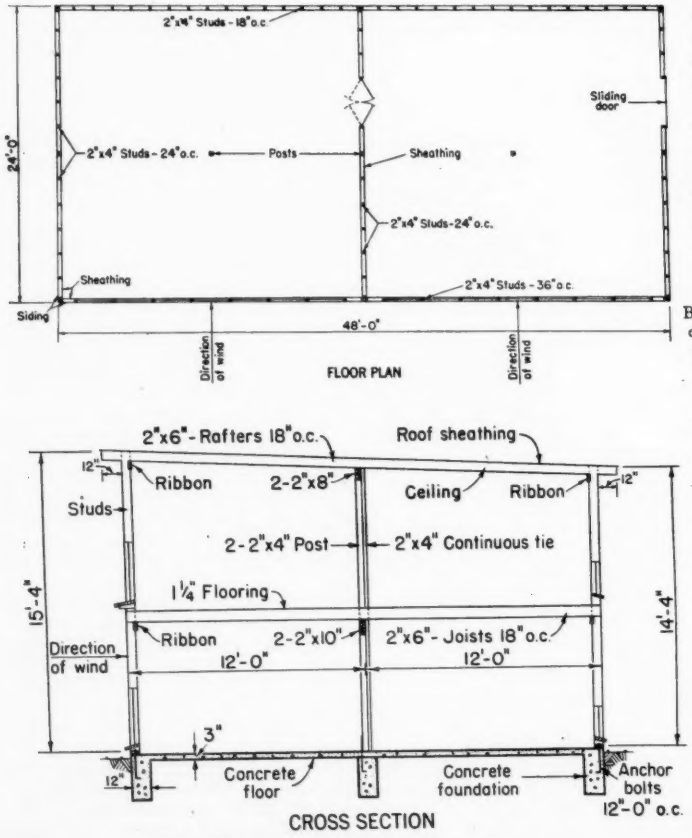



Fig. 1 Two-story, 24x24-ft Connecticut poultry house

3 *Resistance to Wind Forces.* To resist wind forces successfully a building must be designed so as to transmit safely the windload from the roof and wall covering through the frame to the foundation bed. As an example, let us analyze roughly the loads and stresses in the two-story, 24x24 ft Connecticut poultry house (Fig. 1) using two units and a velocity pressure $q$ of 30 lb per sq ft at right angles to the 48 ft x 15 ft 4-in side. Because the building, even with the windows closed, is not windtight, an internal pressure of 0.3 $q$ should be added to external wind pressures.

The slope of the roof is less than 3 deg and the force acting up will be 0.77 $q$ plus 0.3 $q$, or $1.07 \times 30 = 32.1$, say 32 lb per sq ft. The dead load including ceiling is 7 lb per sq ft, leaving 25 lb net uplift. A 6-in-wide roof board would have a net uplift at rafters of 20 lb, and two 6d nails with a safe resistance to withdrawal of 26 lb in northern white pine will be satisfactory. The 2x6-in rafters spaced 18 in o.c. will have end reactions of 225 lb upward and a bending stress of 945 lb per sq in.

Uplift on the eaves is $(1.57 \times 30) - 7 = 40$ lb per sq ft, or 60 lb per rafter, making a total uplift of 285 lb at the wall end. The bending stress in the rafters is well within limits for temporary loading. The anchorage, however, needs special attention. Allowing as much as 25 lb per 8d toenail, it would take nine such nails on each side at the center support and a total of twelve at the ribbon. Such nailing would split the wood and render the joint useless. A ¾-in-wide twisted 18-gauge sheet metal strap with three 6d nails at each end would be good for approximately 300 lb uplift.

Rafters framing into studs should be nailed with four 12d nails to the wide face of the stud. Two 12d nails should be safe for holding the 2x4-in let-in ribbon to the wall studs.

The two 2x8-in roof girders with a span of 12 ft have net end reactions of 1,760 lb upward and a bending stress of 2,080 lb per sq in. Even for temporary loading this stress is high for a main member of the framework, and a two 2x10-in girder section with a bending stress of 1,300 lb is recommended, especially since it also may be required for snow load.

To anchor 1,760 lb from each of two girders by one 2x4-in nailed tie is not feasible. A safe connection would be a 2x10-in splice pad on each side of the girder fastened with three ¾-in bolts to the top of the column and each end of girders, or twelve 20d nails at each girder and twenty-four 20d nails at the top of the column. The post should preferably extend in one piece to the foundation and be anchored for an uplift of 3,520 lb minus the 700-lb dead load from the second floor. Not less than 64 sq ft of the concrete floor should be anchored to the footing with heavy wire mesh or steel rods. In case of no concrete floor, the footing should be designed to withstand the uplift of 2,820 lb.

The let-in rafters over the end walls carry an uplift per linear foot of 40 lb from the eave; $0.75 \times 25 = 19$ lb from the roof. Reaction at the studs is $2 \times 59 = 118$ lb and requires two 12d nails at each joint. The 2x4-in tie in the end walls between roof girder and foundation is satisfactory if fastened to the girder with twelve 20d nails with the help of a splice pad on the other side of the post.

The uplift from the roof on the wall studs in the front and rear walls is 190 lb per linear foot of wall and the dead load from second floor and wall is 105 lb. The front wall studs are spaced 3 ft o.c. and must be anchored to the sill against an uplift of $3 \times 85 = 255$ lb. A sheet metal strap with three 6d nails each end may be used. The rear wall studs should be anchored for a 130-lb uplift.

With the anchor bolts spaced 12 ft apart the bending stress in the two 2x4-in sill, based on a simple span, is 5,730 lb per sq in, and the pull on the bolts 1,020 lb from the uplift. A maximum spacing of 6 ft should be used with a fiber stress of 1,135 lb in the sill and a 510-lb pull on the bolt.

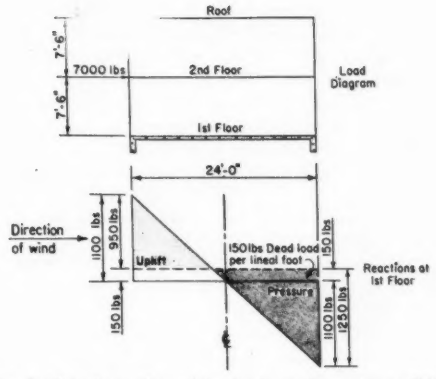



Fig. 2 This shows the racking loads on the center partition

The end walls in this case have no net uplift from suction on the roof except at the columns. The roof is now anchored to the foundation.

The wind loads on the walls are 0.8 $q$ minus 0.3 $q = 0.5$ $q$ pressure in on the front walls, 0.5 $q$ plus 0.3 $q = 0.8$ $q$ suction out on the rear walls, and 0.58 $q$ plus 0.3 $q = 0.88$ $q$ suction out on the end walls. The front wall studs are spaced 3 ft, rear wall studs 18 in, and end wall studs 2 ft. The heaviest load is, therefore, on the end-wall studs and is $0.88 \times 30 \times 2 = 52$ lb per linear foot. Two 6d nails at each stud would be sufficient for 6-in siding. Assuming the studs simply supported at roof, second floor, and sill, the second-story studs will have end reactions of 198 lb and a fiber stress of 1,250 lb per sq in. Provisions must therefore be made to anchor the studs at roof sheathing and sill for a 198-lb pullout and 396 lb at the second-story flooring. Additional fastenings will be required to transmit racking forces from the roof and second floor to the end walls.

The anchorage of the front and rear wall studs should be based on the same suction out per square foot as the end walls to take care of wind parallel to the front and rear walls. The horizontal reaction out for the front wall studs would then be $1.5 \times 198 = 297$ lb at roof and sill and $1.5 \times 396 = 594$ lb at the second floor. The fiber stress would be $1.5 \times 1{,}250 = 1{,}875$ lb per sq in. The reactions and stress in the rear wall studs would be half of that for the front wall studs. The joints between studs, rafters, and joists and also the splices of rafters and joists at the girder supports must be designed to resist these reactions and will require special anchorage.

In order to equalize as much as possible the fiber stress and strength, it is recommended that of all the stud material delivered on the job the best be chosen for the front wall, the poorest for the rear wall, and the balance for the end walls.

Local stresses have now been discussed, but the building must also be designed so that the horizontal loads on the walls are safely transferred to the foundation bed. This, of course, is done by the vertical elements in the building. The load transferred by any one element depends on its relative stiffness in direction of force. For elements of the same material and width, the stiffness would vary as the cube of the depth. (The cube of 0.33 ft = 0.036, and the cube of 24 ft = 13,824.) Although the walls are not solid, *it is apparent that for all practical purposes the 2x4-in studs in front and rear walls have no stiffness as compared to the 24-ft, deep end walls and center partition* when the wind load is at right angles to the front wall.

The end walls and center partition will be assumed to resist all the horizontal forces transferred to them by the horizontal elements — the roof and second floor. The load to be transferred by the roof is the wind force on the upper half of the second-story front and rear walls and that by the floor

is the wind force on the lower half of the second plus the upper half of the first-story front and rear walls. The interior force of 0.3 $q$ on front and rear walls cancel out and the load to be transferred is 0.8 $q$ plus 0.5 $q$, or $1.3 \times 30 = 39$ lb per sq ft of an approximately 15x48-ft wall. The load at the roof is then $3.75 \times 39 = 146$ lb per linear foot and 292 lb at the second floor. Since the rafters and joists are parallel to the wind, the load must be carried by the sheathing and flooring acting as beams between end walls and center partition. The safe load on such beams cannot be calculated and should be determined through large-scale tests. Considering the second floor as 48 individual beams, 1¼x5½ in, the bending stress would be approximately 835 lb per sq in, and a total reaction of 3,500 lb at the supports. The load in this case, however, is probably transferred to the supports by bearing on board to board and nails to joists. This should demonstrate the need for diagonal flooring and/or bracing for long floors.

Assuming the roof and second floor strong enough to transfer the loads to the supports, the load on each end wall would be 1,750 lb at the roof and 3,500 lb at the second floor, and on the center partition 3,500 and 7,000 lb, respectively. The above distribution would be true if the center partition had twice the stiffness of the end walls and the horizontal elements were perfectly rigid. In neither case is this so. The end walls have siding in addition to tongue-and-groove sheathing; the center partition and one end wall each have a door opening. In order to minimize the deflection of the partition and distortion of the roof and floor, the former should be braced substantially with 1x4-in let-in diagonal braces under the sheathing. Time does not permit a full discussion on the subject and readers are referred for further information to the tests made by the USDA Forest Products Laboratory at Madison, Wisconsin, in 1929 on the "Rigidity and Strength of Frame Walls."

The racking force to be transmitted to the partition at the second floor would not exceed 7,000 lb, or 292 lb per linear foot of floor. This would probably be taken care of best by nailing the flooring to 2x4-in blocking between studs. The shear at the roof would be approximately 146 lb per linear foot.

The racking forces at the end walls would be a minimum of 146 lb per linear foot at the second floor and 73 lb at the roof. The maximum load, however, will depend on the rigidity of the horizontal elements and the relative rigidity of the vertical elements. It would be safer, therefore, to make the joints at the end walls of the same strength as at the partition.

The racking load applied at the roof and second floor level tends to overturn the vertical elements. The moment from the racking loads on the center partition at the top of the foundation is 105,000 ft-lb, causing a total uplift of 6,560 lb on the front half and a similar down pressure on the rear half of the partition. These reactions have a triangular distribution (Fig. 2) with zero load at the center line and 1,100 lb at the front and rear walls. If we consider the dead load of the partition and a 4-ft wide strip of roof and floor, the total net uplift will be reduced to 5,670 lb with 950 lb at the front wall. The down pressure at the rear wall will be increased to 1,250 lb. The floor should be reinforced with heavy wire mesh for a width of 6 ft or a foundation wall provided to resist the uplift and the partition anchored securely. The end walls should, as a matter of safety, be anchored for similar loads. The total overturning moment for the building, as taken at the bottom of the rear wall foundation, is only about 33 per cent of the resisting moment from the dead load and the building is, therefore, safe if properly anchored and braced.

From this analysis it is apparent that the common practice, especially in dairy-barn designs, of placing door openings near the corners in end walls is undesirable from a structural point of view. If doors are needed close to the corners, it would be much safer to place them in the long sidewalls.

When the wind is at right angles to one of the 24x15-ft end walls, the horizontal forces to be distributed to the walls are only half as large and the resisting walls are twice as long. The front wall with all its openings is by far the weaker of the two and the rear wall will, if the horizontal elements are rigid enough, absorb most of the load. As the load on the front wall depends on the uncertain factor of the rigidity of roof and floor, it is recommended that this wall be provided with let-in diagonal braces wherever practical.

When the wind direction is other than at 90 deg, all walls will absorb the load in an amount depending on their respective orientation to the wind and their relative rigidity. If the building is designed for windload at 90 deg to the side and end walls, however, it should be strong enough to withstand wind from any other direction.

## Garden Tractor to Replace Carabao?

TO THE EDITOR:

I WOULD like to take this opportunity of acquainting you with one, we think, interesting thing which we are considering. In a previous letter I mentioned that I am managing a large family corporation dedicated to diversified farming — truck farming for one. In line with this I am about to order a few units of garden tractor. Several of my friends, who knew of my plans, discussed the possibilities of garden tractors in the Philippines, and we emerged from our discussion awed by its vast possibilities.

The carabao, the backbone of our primitive agriculture, and probably the remote cause of much misery and trouble in our rural areas, was almost wiped out by the exigencies of the last war. We were thinking that, if we could adapt the garden tractor to our paddy rice culture, we could not only make use of tens of thousands, if not hundreds of thousands, of this machine to replace our carabaos, but also modernize (make more efficient and economical and less laborious) our rice culture, without radically disrupting the social setup based on it and abandoning its most redeeming feature, almost perfect soil erosion control by the use of terraces.

If we succeed in this project, American machines will find an eager market. Personally I do not believe that our rice culture could be mechanized extensively by the use of the common tractor and agricultural implements, except in irrigated areas, and, even at that, varieties have to be changed or developed and soil erosion control, even with contour farming, would be most difficult to accomplish with our long torrential rains. Also, nobody knows what to do with the unnecessary farm tenants and hands that would be displaced by the big machines, because we are far from industrialized.

At the present writing, many lives are being lost in a minor civil war raging in our central plains, the center of rice production by carabao power, over who should get the larger share of the crop — the landlord or the tenant. With the use of the garden tractor, if we could use it — and I think that with some experimentation we could — the only change to be made would be from carabao to garden tractor. The garden tractor is about three to four times more efficient than the carabao, costs about the same at the present writing, and, most important, the carabao has to be fed the greater part of the year, while the garden tractor does not.

SANTIAGO R. CRUZ
**A.S.A.E. Member**
**Manila, Philippines**

This "Agro Engineers" float was devised by members of the Saskatchewan Student Branch of the American Society of Agricultural Engineers in connection with Reunion Day at the University of Saskatchewan. A stationary engine inside the float revolved the drum at slow speed. The colors used were yellow and black

# Rates of Runoff from Small Drainage Basins

By D. B. Krimgold
MEMBER A.S.A.E.

IN 1938 the author presented a paper, entitled "Runoff from Small Drainage Basins"[4*], before this society, and I can think of no better introduction to what I have to say today than to refer to my earlier paper in which were discussed the status of the runoff problem, the various runoff formulas, the rational method, and the infiltration theory of runoff. The earlier paper contained also a brief description of runoff studies which were then being established by the U. S. Soil Conservation Service. Hydrologic research in general and runoff studies in particular are by their very nature incapable of producing results quickly. There is no known way in which the processes involved can be accelerated as in chemical and even biological laboratories. We cannot, for instance, produce rains of desired amounts and intensities at will on areas greater than a very small fraction of an acre, neither can we regulate nor control such factors as temperatures and conditions of vegetal cover. It is for this reason that even now, after runoff studies from small drainage basins in various parts of the United States have been in progress for periods varying from 6 to 8 years, little in the way of tangible practical results has become available.

Some people, including even agricultural engineers who should know better, have always been dubious about solving runoff and other practical hydrologic problems through properly conducted research. After the first records from the runoff studies became available, even some of us who have been close to this work began to feel discouraged. The reason for this was that we had preconceived ideas about the factors affecting runoff and about the relationships between them. For instance, many of us, including the author, were at one time naive enough to think that all that was necessary to arrive at rates of runoff was to obtain a few values of *C* and of "times of concentration." The early records from the runoff studies served to dispel this and other notions about runoff from small drainage basins.

The analysis of these records[7,1,2] showed that the expectancy (frequency) of runoff is not the same as the expectancy of rainfall intensities. In fact, the peak rates of runoff produced by rainfall of given amounts, distribution, and intensities cannot be expected as often as the rainfall. This is because rates of runoff from a given area are the result of a combination of rainfall or snow-melt characteristics and of concurrent watershed conditions. The expectancy of a combination of factors is always rarer than the expectancy of any one of the factors. The early results from the runoff studies showed also that rates of runoff from small natural drainage basins are not a simple fraction of the rate of rainfall. As more information became available, our concept of runoff from small drainage basins began to crystallize. In the light of this information, the factors affecting rates of runoff and their interrelationships can best be described as follows:

Rates of runoff from natural drainage basins are determined by the hydraulic efficiency of the disposal system (rills, watercourses, and channels) of the basins, by the rate at which water becomes available for runoff and by the total runoff. With a given amount of water available for runoff, the rate at which it leaves the drainage basin will increase with the slopes and hydraulic radii and decreases with the retardance (roughness, meanders) of the rills, furrows, watercourses, and channels. Rates of runoff will also increase with the rate at which water reaches the channels; that is, they will be higher when the length of overland flow is shorter. Paved areas have fixed disposal systems so that the velocities in the system, and therefore the rates of runoff, are determined by the amount of water available for runoff and the rate at which it becomes available. In natural drainage basins, especially in small ones (a few hundred acres), the disposal system is not rigidly fixed. On cultivated areas the direction of cultivation and tillage methods may change the efficiency of the disposal system many times. Even the seemingly fixed watercourses on pastured or wooded drainage basins may undergo important changes in the course of one growing season.

On paved areas with a fixed disposal system the amount of water available for runoff and the rate at which it reaches the disposal system is determined by the amount and intensity of rainfall or by the amount and rate of melting of snow. On natural drainage basins the relationship is not quite as simple. What happens here can best be described by a simple analogy. Consider a barrel covered with a sieve. Now let us install a pump and a spigot. If the sieve is coarse, water can be poured into the barrel rapidly as long as the barrel is not full. Once the barrel is filled, additional water can be poured in only as fast as it can drain out through the spigot and/or be removed by the pump. If the water is poured in faster, part of it will spill over.

Now let us think of the sieve as the openings in the surface of the soil, and let us consider the size of the barrel as the pore space in the soil which can be readily occupied by water. Now look at the speed with which the water can flow out of the barrel through the spigot as the speed with which water can move through the soil. Let the pump in our setup represent evaporation from bare soil and the action of trees, grass, and annual crops and weeds which during the growing season literally pump the water out of the soil. The name for this pumping action is "transpiration." The amount of water removed from the soil by transpiration is greater by far than that removed by direct evaporation. Transpiration varies with the kind and size of plants, and of course, with the number of plants per unit area. When the plants are dormant or dead, there is little or no transpiration. Natural watersheds represent a wide variety of combinations of sieves of various degrees of coarseness, barrels of various sizes, with spigots and pumps of large ranges in size and efficiency. Furthermore, the coarseness of the sieve in any given case does not necessarily remain the same. Also the barrel while of more or less fixed size may be nearly empty, half full, or full. The size and efficiency of the pump vary greatly during the growing season. The size of the spigot varies with the sizes of the pore spaces in the soil which in turn are determined by root channels, worm holes, cleavages, and by size and arrangement of soil particles and of aggregates.

To show the effect of various combinations of conditions on amounts of water available for runoff and on the rate at which it becomes available we shall consider two cases. First, let us take a field with a shallow clay loam soil (barrel and spigot small). The crop is corn or cotton. The time is early

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D. B. Krimgold is soil conservationist, division of drainage and water control, Soil Conservation Service, U. S. Department of Agriculture.

NOTE: This paper is a contribution of the Subcommittee on Runoff of the A.S.A.E. Committee on Agricultural Hydrology. It is the intention to follow this introductory article with a series of papers which will constitute the first symposium sponsored by the Subcommittee.

*Superscript numbers refer to appended references.

summer. The plants are small. The field has been cultivated up and down hill. Little of the water which accumulated in the soil during the spring has been removed by evaporation or transpiration. There is little unoccupied space in the soil (small barrel nearly full). Now comes a heavy downpour with large raindrops. The raindrops destroy the aggregates in the surface and the soil is partly sealed (the sieve is made finer). Muddy water containing the soil particles dislodged by the raindrops accumulates rapidly in the furrows. It stands about ½ in or 1 in deep. Presently it begins to move. However, with the shallow depth the small amount of water is insufficient to overcome the little obstacles represented by irregularities in the bottom and in the sides of the furrows. The speed of the water is effectively checked and the small rivulets are barely moving. But if the rain continues, this condition is only temporary. Before very long the water in the furrow becomes so deep that it has enough momentum to overcome and to eliminate the obstacles. It now begins to move at a *progressively increasing speed.* With sustained rainfall, additional water is continually flowing into the furrow. This additional water increases the momentum. It does so both by increasing the mass as well as the velocity, because when the water in the furrow becomes deeper its hydraulic efficiency becomes greater; and greater hydraulic efficiency means higher velocity. This process builds up rapidly as the water moves down and reaches a well-defined natural channel.

Now if what we have said so far is not too involved, we can readily arrive at the following conclusions: Heavy rains falling on medium to heavy-textured soils, unprotected by vegetation and cultivated in straight rows up and down hill, will produce a great deal of surface runoff. The excess water will move fast and will reach the natural watercourse quickly. On small drainage areas the variations in volume and speed of the water reaching the natural watercourse during a storm will follow closely the variations in rainfall. The water running off the field will carry fine soil particles in suspension and a good deal of heavier material along the bottom of the channels. Slow rains with small raindrops will produce less and lower rates of runoff and less erosion. Just how much less and slower the runoff will be will depend on how slow the rain is and on whether or not it comes when the soil is wet, and on whether or not it lasts longer than necessary to saturate the soil. Subsurface runoff from small drainage areas will, under such conditions, be very slow and will not amount to much.

## WHAT HAPPENS UNDER FAVORABLE CONDITIONS?

Now let us consider another set of conditions. Let us see what happens on a field with a deep, open, well-aggregated soil with a good two or three-year stand of alfalfa or grass (coarse sieve, large barrel, large spigot and large efficient pump). The time is midsummer. Since the last rain, the plants have pumped a lot of the moisture out of the soil. The roots and microorganisms have given the soil a good firm open structure. The plants are about 8 in high and completely cover the surface of the soil. Down comes the same intense rain. What happens? The heavy raindrops are intercepted by the foliage. They then fall on the soil through a distance of only 8 in, mostly less. When the raindrops reach the soil, they have practically no speed and no momentum. Besides, the soil between the stems of the plants is likely to be protected by dead leaves and stems. There is practically no destruction of the soil structure. The open thirsty soil takes all the water that reaches it. A good deal of the water moves through the soil toward the channels or downward to the water table.

But like the barrel with the sieve, the spigot and the pump, even such a soil, given enough water applied at high enough rates, will sooner or later cease to take up water as fast as it is applied. Now let us see what happens. Water slowly begins to accumulate on the surface between the stems of the plants. Because there are no well-defined rills or furrows, the water does not concentrate rapidly. Nevertheless a point is eventually reached when the water begins to move under the influence of gravity. But it has a hard time getting up any speed. The stems and the litter are spaced so closely that, even on steep slopes, the water can seldom develop sufficient speed to break through.

Now we can say that runoff from fields with deep open soils and dense vegetation will have the following characteristics: The total amounts of runoff will be small. A good proportion of the runoff from large areas may be subsurface flow. The amount of subsurface flow will depend on the slope of the impeding stratum and on its position relative to channels, streams, and watercourses. The excess water will move slowly. The time lag between rainfall and runoff will be great. The variations in rainfall during a storm will be reflected directly only on very small drainage basins, and even there only in a general way. There will be no erosion except bank cutting in larger streams during floods derived largely from subsurface runoff.

What we have just said about good grassland applies also to woodland with a good litter. What was said about rainfall applies to melting snow, except that the action of raindrops is replaced by slackening action of still water and the variations in intensities of rainfall are replaced by variations in rate of melting.

## NATURE AND MAGNITUDE OF VARIATIONS

One can readily see why the records from small agricultural drainage areas with constantly changing vegetal cover, soil moisture and structure of surface soil show such great variations in peak rates of runoff which overshadow the relation to intensity of rainfall. The articles already referred to and the following quotation from a paper by H. K. Rouse[8] show the nature and magnitude of these variations. Referring to the runoff studies near Vega, Texas, Rouse states:

> ". . . vegetal cover on range land was in very low condition in 1938 . . ."
>
> "The following years saw relief from overgrazing and successive wet years in 1941 and 1942 resulted in great improvement in both density and volume of vegetation. This continued in 1943. As a result, the highest rates of precipitation recorded in our period of record resulted in negligible rates and amounts of runoff. For example, on a 130-acre watershed, on May 30, 1938, the maximum rate of runoff recorded for the entire six-year period of record was 110 cu ft per sec. On May 27, 1943, just five years later, a storm 14 to 25 per cent more intense produced a maximum rate of only 2½ cu ft per sec.
>
> "Again, on the 96-acre watershed, the maximum rate of 141 cu ft per sec also occurred on May 30, 1938. A little more than four years later a maximum storm 14 to 27 per cent more intense resulted in a peak rate of runoff of less than 4 cu ft per sec.
>
> "These records of storms about 15 per cent less intense producing runoff 30 to 40 times as great are startling. Yet the amounts of precipitation during the 15 days preceding runoff were fairly comparable in both examples. The only noticeable changes in the watersheds during the intervening years were in vegetation and in the organic litter on the ground surface and probably some changes in the condition of the soil due to plant growth and canopy shelter. An even closer parallel has occurred on the project near Colorado Springs, and at this location it was possible to compare runoff from native pasture with that from a cultivated watershed. On July 15, 1944, the most intense rainstorm in the seven-year record occurred on these adjacent watersheds. The slopes and soils of the two watersheds are similar. Resulting from this storm the rate of runoff from the cultivated land was 90 times as great as from the watershed with native pasture cover. The amount of water lost — that is, runoff — from the cultivated watershed was 56½ per cent. This compares with a 1½ per cent loss from the native pasture watershed."

The effect of changes in conditions of vegetal cover and of soil structure on the watershed in native pasture near Colorado Springs are reported by Rouse as follows:

". . . In comparing the storm of maximum intensity on July 15, 1944, with the next most intense storm of July 21, 1940, which produced the highest peak rate and greatest amount of runoff, all conditions except vegetal cover were as similar as is apt to be found under natural conditions. The storms were similar in intensities in critical periods and in total rainfall. They occurred at the same time of the year and at about the same hour of the day. The precipitation during the two weeks previous and for the six months previous was fairly comparable. The boundary of the watershed is defined by an artificial ridge precluding entrance of water from outside the watershed or loss of water to the outside. There had been no appreciable disturbance of soil or of topographic features.

"With no significant difference in physical characteristics, the only variable factor is in the vegetation and changes in the soil conditions induced by changes in vegetation in a four-year period. There were pronounced changes in vegetation as are indicated by photographs of quadrats taken at the end of the two growing seasons. The condition of vegetation in 1940 was not good. . . . In marked contrast, 1944 was a year of good growth and a marked recovery in density had taken place since 1940.

"The 1940 rain storm averaged 5 per cent less intense and was 10 per cent less in total amount than the 1944 storm but produced runoff at a rate 27 times as great and in an amount 29 times as great."

We could cite numerous additional examples from existing records. We could also go on to describe what happens in all intermediate cases, such as fallow land, land in drilled crops and grasslands and meadows with all degrees of density of cover, and all types of soils. It is, however, not necessary to do so to show how futile it is to try to relate rates of runoff from small agricultural watersheds to one factor — intensity of rainfall — or what is even worse, to assume that the "frequency" of a runoff rate is the same as the "frequency" of some rainfall intensity. It is important to remember in this connection the differences between large and small drainage basins. Tillage practices and conditions of crops and of vegetation change just as much on large drainage basins (many square miles) as they do on small ones comprising one or two 40-acre fields and often only a fraction of such a field. On large areas the effects of such changes may and often do cancel out. They do not on small ones.

## NEW APPROACH TO RATES OF RUNOFF PROBLEM

Having studied numerous records from small drainage basins and having arrived at a clearer understanding of the factors and processes involved, one naturally must ask the following questions: What is the virtue of the rainfall-runoff relationship? Why try to arrive at rates of runoff in a roundabout way? Would it not be more logical to try to derive design values directly from actual runoff records? The answer to the last question is, Yes, but there are no long-term records of runoff. Here is where the difference between ordinary and applied research comes in. A research worker normally reserves the privilege of refraining from drawing conclusions until sufficient experimental evidence is obtained to warrant them. The engineer engaged in applied research is usually denied this privilege. He is expected to devise coefficients and safeguards which will make possible the utilization of the available limited results in developing practical methods and procedures for immediate application. He is also expected to be open-minded and, if necessary, to be ready to revise his recommendations when additional information becomes available. This attitude led the author to a new approach which was presented at a research seminar of the Soil Conservation Service on October 30, 1943. This new approach to the problem of rates of runoff involves the following:

1 Application of probability analysis directly to short records of runoff.

2 Testing the short periods of record to determine how closely they represent longer periods with respect to watershed conditions, precipitation, and other factors.

3 Determination of rates of runoff for various expectancies from the results of the probability analysis and of the tests referred to under (2).

4 Designation of the general physiographic and soil provinces and of specific conditions within them to which the rates of runoff are applicable.

5 Determination of relationship between size of drainage area and peak rates of runoff for each area of application.

The discussion of each of the five steps just outlined merits one or more papers. The author has formulated tentative procedures which have already been used in developing rates of runoff for design of conservation and similar structures on small drainage basins in the Claypan Prairies[5,6]. These procedures are being constantly revised and improved. At this writing, modified and improved versions of them are being used in the preparation of publications on rates of runoff for the following physiographic and soil provinces: Coastal Plains of New Jersey, Delaware, and Maryland; Ridges and Valleys in Virginia; Loess Areas in Wisconsin, Minnesota, Iowa, Illinois, and Missouri; Western High Plains of Nebraska, Kansas, and Wyoming; Western High Plains of Colorado and New Mexico; Western High Plains of Oklahoma and Texas Panhandles, and Ozark Plateau.

## PROCEDURES TO BE SUBJECT OF PAPERS

The Subcommittee on Runoff of the A.S.A.E. Committee on Agricultural Hydrology is planning to make these procedures subject of a series of technical papers in AGRICULTURAL ENGINEERING. It is intended that these papers shall give ample opportunity for presenting divergent views that must necessarily exist in the early stages of development of such an approach. There is no better way to test and improve such procedures than in open free discussion such as these papers will afford.

TABLE 1. RATES OF RUNOFF FOR DESIGN OF CONSERVATION STRUCTURES ON CULTIVATED AND LIKELY TO BE CULTIVATED LAND IN THE COASTAL PLAINS OF NEW JERSEY, DELAWARE AND MARYLAND

(Note: The rates shown in this table do not apply to CROPLAND TERRACES or to DIVERSION TERRACES)

| Drainage area, acres | Rate of runoff, cfs Case A | Case B | Drainage area, acres | Rate of runoff, cfs Case A | Case B |
|---|---|---|---|---|---|
| 2 | 15 | 19 | 22 | 77 | 105 |
| 3 | 20 | 25 | 23 | 80 | 108 |
| 4 | 24 | 31 | 24 | 83 | 111 |
| 5 | 28 | 36 | 25 | 85 | 114 |
| 6 | 32 | 41 | 26 | 87 | 118 |
| 7 | 36 | 46 | 27 | 90 | 121 |
| 8 | 39 | 50 | 28 | 92 | 124 |
| 9 | 42 | 55 | 29 | 94 | 127 |
| 10 | 45 | 59 | 30 | 96 | 130 |
| 11 | 48 | 63 | 31 | 98 | 133 |
| 12 | 51 | 66 | 32 | 101 | 135 |
| 13 | 54 | 70 | 33 | 103 | 139 |
| 14 | 57 | 74 | 34 | 105 | 141 |
| 15 | 60 | 78 | 35 | 107 | 144 |
| 16 | 62 | 81 | 36 | 109 | 146 |
| 17 | 65 | 85 | 37 | 111 | 150 |
| 18 | 68 | 88 | 38 | 113 | 152 |
| 19 | 71 | 92 | 39 | 115 | 155 |
| 20 | 73 | 95 | 40 | 117 | 157 |
| 21 | 75 | 102 | | | |

Case A applies to *sloping land* with light-textured, deep, well-drained soils, such as Collington, Freehold, Sassafras and Hyattesville *loams;* Freehold, Sassafras and Collington *sandy loams,* and similar soils.

Case B applies to *sloping land* with medium-textured, imperfectly drained soils underlain by a very slowly permeable hardpan at a depth of about 25 in, such as Beltsville silt loam, loam, gravelly silt loam and gravelly loam, and similar soils.

There is as yet no positive proof that the suggested procedures will produce desired results in all cases. Neither is there as yet complete agreement among workers in this field as to how the various steps can be best performed. However, the work done since 1943 indicates that this approach has merit and is capable of developing into a sound workable procedure; it has made it possible to make the results of the runoff studies available with a fair degree of assurance that the information is better than the various formulas and methods heretofore used. The new approach also makes possible the furnishing of definite values in tabular and graphical form to field personnel. A good idea as to the form in which this information is being made available can be gained from Table 1 and Fig. 1, and the following excerpts from a statement prepared for the publication on peak rates of runoff in the Coastal Plains[3]:

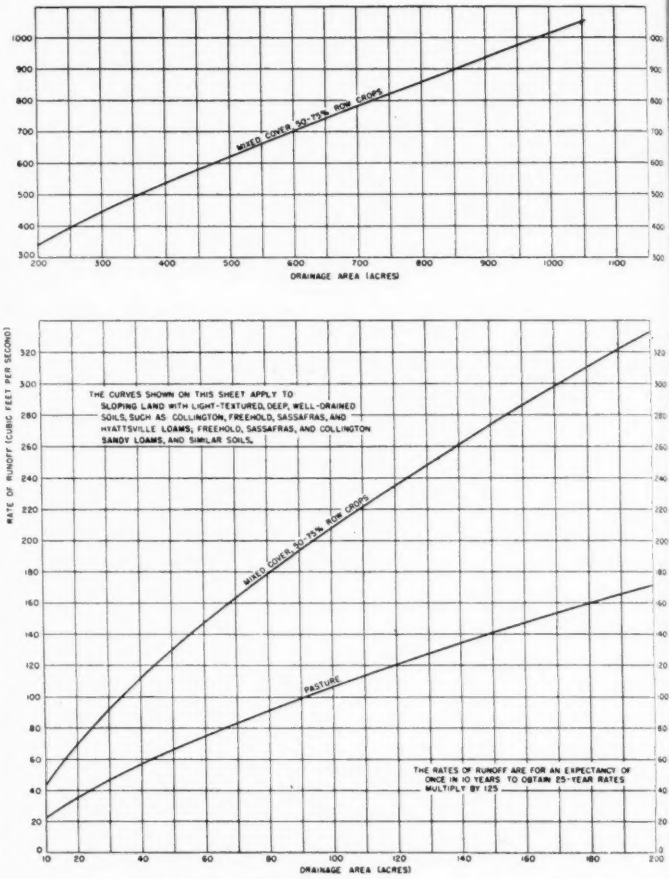
MIXED COVER, 50-75% ROW CROPS
DRAINAGE AREA (ACRES)
RATE OF RUNOFF (CUBIC FEET PER SECOND)
THE CURVES SHOWN ON THIS SHEET APPLY TO SLOPING LAND WITH LIGHT-TEXTURED, DEEP, WELL-DRAINED SOILS, SUCH AS COLLINGTON, FREEHOLD, SASSAFRAS, AND HYATTSVILLE LOAMS; FREEHOLD, SASSAFRAS, AND COLLINGTON SANDY LOAMS, AND SIMILAR SOILS.
MIXED COVER, 50-75% ROW CROPS
PASTURE
THE RATES OF RUNOFF ARE FOR AN EXPECTANCY OF ONCE IN 10 YEARS TO OBTAIN 25-YEAR RATES MULTIPLY BY 125
DRAINAGE AREA (ACRES)

Fig. 1 Rates of runoff for design of conservation structures in the coastal plains of New Jersey, Delaware, and Maryland

"There are practical considerations which must be remembered in the hydrologic design of small structures. Cropping plans in effect at the time a structure or a practice is being planned may not necessarily be followed in the future. Circumstances may require a farmer to change his farming operations and the proportion of land in cultivated crops. Pastures or meadows may be plowed up. Ownership may change and the entire farm plan may be revised. Because of these uncertainties, it is necessary to assume conditions conducive to higher rates of runoff where changes can be reasonably expected to occur within the economic life of the structure.

"In planning a diversion on a pasture which includes plowable land, it is advisable to design it for runoff from cultivated land rather than for that from pasture. On the other hand, if the pasture is steep, rough, rocky or stumpy, it would not be reasonable to design the diversion on the basis of runoff from cultivated land. In case of structures on small drainage areas one must also remember that small differences in rates of runoff would result in practically negligible changes in the cost of the structure.

"The results of the analyses of the experimental data tempered by such practical consideration made it possible to arrive at rates of runoff to be used in determining capacities of spillways, ditches, culverts, terrace outlet channels, and similar structures on small watersheds. Values for drainage areas ranging up to 40 acres for land likely to be cultivated, for pastures, for woods, for terraced areas, and for diversions, are presented in Tables 1 to 5. Rates of runoff for larger areas are given in Figs. 1, 2, 3, and 4. The tables are intended for the smaller structures, the planning of which is usually entrusted to subprofessional employees. The curves which apply to larger areas and involve large flows should be used by engineers and technicians of higher qualifications. The tables and graphs have been so designed that they can be incorporated in handbooks or instructions of agencies such as the Soil Conservation Service, Agricultural Adjustment Administration, state highway departments, and of other agencies concerned with the planning, construction and financing of structures and of conservation practices on small agricultural drainage areas.

*"The attention of prospective users of the tables and graphs is called particularly to the statements describing the conditions to which the values are applicable. Using those values in cases other than those described would result in either too frequent failures or in uneconomical design and would defeat the whole purpose of this publication.*

"The analyses show that the values in the tables and the graphs can, on the average, be expected to be equalled or exceeded once in 10 years. It is assumed that small structures on areas not exceeding 40 acres need not and should not be designed for higher values. Structures on larger areas covered by the graphs may, under certain conditions, be designed to carry flows which can on the average be expected to be equalled or exceeded once in 25 years. When this is the case, the coefficient given in the graphs should be applied to the values shown by the curves."

The foregoing statement and the tables and figures will, of course, not apply directly to other areas than the Coastal Plains of New Jersey, Maryland, and Delaware. They do, however, illustrate the form in which it is aimed to make the results available. Only one of the tables and one of the graphs referred to in the quoted statement are shown (Table 1 and Fig. 1). The others are similarly arranged.

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# Runoff as a Phase of Agricultural Hydrology

By D. B. Krimgold
MEMBER A.S.A.E.

RUNOFF has been set up as the subject of one of the six standing subcommittees of the Committee on Agricultural Hydrology[1*] of the American Society of Agricultural Engineers. It is the purpose of this paper to discuss runoff in its relation to agriculture and to outline the scope and proposed activities of the Subcommittee on Runoff.

Runoff is that part of precipitation (rainfall or melting snow), which is not retained on or in the soil, is not disposed of by evapotranspiration, and finds its way into watercourses through surface or subsurface flow.

In agriculture we are concerned with two aspects of runoff: (1) Runoff as an eroding and sedimentation agent and as the source of flood water and (2) runoff as a source of water for livestock, irrigation, fish production and other uses on the farm. Subsurface flow is often thought of only as beneficial. Yet, under certain conditions, it can prove to be a serious destructive agent. Subsurface flow is responsible for gullying of land with unconsolidated sandy or gravelly subsoils. Debris-laden flood flows from heavily forested, permeable but shallow soils are derived largely from subsurface flow.

When considering the erosion and flood aspect of runoff, one must think in terms of rates of runoff, since the velocity of flowing water is the principal if not the only factor in water-borne erosion. Floods from small drainage areas are caused not so much by large quantities of water as by the rate at which surface runoff concentrates and accumulates.

*Rates of Runoff.* Rates of runoff as a hydrologic phenomenon are the concern of the hydrologist. As a destructive agent responsible for soil erosion, inundation, and siltation of agricultural land, rates of runoff are the concern of the agriculturist and particularly of the agricultural engineer. In treating this phenomenon, both the hydrologist and the agricultural engineer must consider its magnitude, the individual factors affecting it, and the interrelationship between these factors. The agricultural engineer must also consider practical means of modifying rates of runoff with a view to eliminating or reducing their destructive power.

Rates of runoff from large drainage areas (streamflow) have been observed and recorded for many years. It is only recently that reliable records have become available from small drainage areas such as are commonly dealt with in agriculture. Many of these records afford an opportunity to evaluate the factors involved and to determine the magnitudes of rates of runoff, which must be considered in the proper design of control measures.

The Subcommittee on Runoff can perform a substantial service and make a worthy contribution by initiating a symposium and round-table discussion on design values and factors affecting rates of runoff from small agricultural watersheds. Such a symposium and round-table discussion will serve to review the status of the problems in the light of the new factual data, to clear up such misconceptions as may exist, and to arrive at recommendations for procedures and standards to be accepted by the profession. They may also serve to point out deficiencies in existing information. The first paper of such a symposium, presented at the 1946 A.S.A.E. annual meeting, appears elsewhere in this issue of AGRICULTURAL ENGINEERING[2]. Members of the Society and others interested in this subject are urged to take part in this symposium by reporting their views and findings in similar papers.

*Amounts of Runoff.* Until rather recently agriculturists, including agricultural engineers, have considered total runoff only in its negative aspects. Amounts of total runoff from small plots have been measured for many years to indicate the effectiveness of vegetation and of erosion control measures. It was only recently that measurements of total runoff from small drainage basins were begun with a view to utilizing the information in the proper management of that part of precipitation which cannot be retained in the soil. The rapidly expanding use of farm ponds and small reservoirs in storing runoff for stock water, supplemental irrigation, and for other purposes on the farm is presenting a series of hydrologic problems of great complexity. One of these problems is the occurrence and distribution of runoff. How much runoff can be expected from small agricultural drainage areas with various soils, vegetation and tillage practices in the several climatic regions? What are the expectancies of various amounts of runoff? Is there a definite relationship between runoff from small areas and monthly, seasonal, or annual precipitation? How does total runoff per unit area (surface and subsurface) vary with the size of drainage area? These are some of the questions which must be answered before hydrologic design of ponds and reservoirs can be put on a rational basis. Measurements of runoff from small agricultural areas have been carried out for nearly a decade in various parts of the United States. A good deal of this work has been done by members of A.S.A.E. The information already available may prove sufficient to answer some of these questions. The Subcommittee on Runoff is planning to initiate a symposium on the subject of total runoff and is inviting suggestions and papers from members as well as non-members.

*Effects of Land Use and of Conservation Practices.* The evaluation of the effects of land use and of conservation practices has occupied the minds of hydrologists and conservationists in this country and abroad for almost a century. An excellent summary of the literature on this subject up to 1930 was made some years ago by Lowdermilk[3]. With few exceptions the 42 references included in this summary deal with the effects of deforestation or afforestation on the regimen of streams (flood flows, total runoff, and minimum flows). Relatively few of the references deal with results of controlled experiments. Of the few experiments conducted prior to 1930, only the Emmenthal[4], the Wagon Wheel Gap[5], and the Great Basin[6,7,8], were continued long enough to justify conclusions.

Since 1930 a vast amount of experimental work has been carried out primarily in the United States to determine the effects of land use and of conservation practices on runoff. Experiments involving watersheds ranging from a few acres to several square miles in size have been established in various parts of the United States. There are many instances where reliable records of rainfall runoff and of related hydrologic phenomena are available for as much as 10 years or longer. Even a 10-year record may in some instances not be sufficient to draw definite conclusions. But how shall we know without trying? Baird[9] and Hobbs[10], both members of A.S.A.E., have made a start of analyzing some of these records with a view to determining the effect on rates of runoff. In spite of all the work referred to already and the great amount of public funds spent in recent years on flood control surveys, the need is still urgent for definite conclusive information on the effects of land use and conservation practices on rates (floods) and amounts of runoff. In the concluding discussion of their paper, "Forests and Streams Flow," Hoyt and Troxell[11] say:

> "... Controlled experiments on small plots, to which reference is made by Messrs. Bates and Lowdermilk, are unquestionably of value, but there is grave doubt as to their application to natural watersheds in so far as water yield or net erosion is concerned ..."

Ten years later Hoyt and Langbein make the following statement in their discussion of Horner's paper, "Role of the Land During Flood Periods"[12]:

> "... The author presents curves of infiltration capacity for soils typical of the Texas Blacklands that show marked differences .... in surface runoff for different kinds of land use. These curves are based on measurements of runoff on small homogeneous catchment areas at the Waco watershed and the Garland Runoff Studies Project. There is no reason to believe that these curves do not reflect the qualitative effects of cover on the surface runoff of the small homogeneous areas for which they were derived. There is nothing in the report, however, to demonstrate that a river such as the Trinity River would respond to changes in land use in the same way as the small homogeneous plots. Thus, ... there is still lacking a process for evaluating the effect of land-use change on flood stages and flows which is not open to considerable doubt."

Early in 1945, Cook[13], and more recently Zing[14], member of A.S.A.E., summarized the results of some of the studies conducted under the Omnibus Flood Control Act of 1936.

Agricultural engineers, as citizens qualified to judge such matters as well as in their capacities of administrators and technicians in the public service, are deeply involved in this problem of flood abatement by head-water measures. To properly discharge their professional and civic responsibilities, they must know whether the results of controlled experiments conducted over a period of years do or do not support these conclusions, which of necessity were based on many assumptions and on meager records. What can we now say about the following diametrically opposite views:

> "... If the ground is otherwise worthless, reforestation may be a sound solution, by putting the area to some economic use and preventing undesirable phenomena such as dust storms or the sedimentation of streams. But *the problem of preventing erosion is inherently different from that of flood control.* Forestation as an aid in its solution should be considered on its merits, without bringing in unfounded claims of its benefits to flood control ..."—From paragraph 143, page 44 of "Engineering Construction-Flood Control," Engineering School, Fort Belvoir, Virginia, 1940.

> "... Forests and all vegetative cover affect the stream flow ...
>
> "Floods are reduced, low water periods are lessened, the low water flow is maintained at a higher level, and springs are stabilized by the presence of a forest cover, other soil covers decreasing in importance and influence with decreasing density and size.
>
> "Deforestation and devegetating an area is responsible for the increase in floods ..." — From page 49 of "Erosion and Flood Problems in California," California State Board of Forestry, 1923.

The conclusion from the flood control investigations reported by Cook[13] and Zingg[14] would indicate that neither of the above views is

*The superscript numbers refer to literature cited.

right. The results of the Wagon Wheel Gap[5] (222.5 and 200.4 acres) and Emmenthal[4] (137.5 and 172.2 acres) experiments have shown, though not conclusively, that there is little if any difference in the effects on total runoff of dense forests or of a lower type of vegetation such as brush and a good stand of grass. The Great Basin[6, 7, 8] experiment (11.24 and 8.97 acres) and many other studies indicate definitely the tremendous effect of land use and of conservation practices on erosion.

Published results of more recent studies leave no doubt about the effects of good grass or forest cover on both rates and amounts of runoff *from small areas with deep permeable soils*. On the other hand, there is fairly good evidence that on shallow, very slowly permeable soils, such as in the Claypan Prairies[15], neither rates nor amounts of runoff are greatly affected by grass cover even on small areas.

But what does the new information show for larger areas? My studies of records from small watersheds under various conditions indicate that the quoted statements by Hoyt and Langbein cannot be brushed aside.

Hoover and Hursh[16] and Brater[17] reported rates and amounts of runoff and hydrographs for the Coweeta, Bent Creek and Copper Basin Experimental Watersheds, ranging in size from about 5 to nearly 2000 acres. Hydraulic Bulletins No. 1[18] and 4[19] of the U. S. Department of Agriculture report rates and amounts of runoff for 1939 and 1940 from a number of areas less than 3 acres, from a 43.6-acre watershed in woods, and from 16 mixed-cover watersheds with and without conservation practices, ranging in size from 29 to nearly 4600 acres in the North Appalachian region (eastern Ohio). Bulletin No. 2[20] in the same series contains similar data for 1937-1939 from a number of areas less than 4 acres and from cultivated and mixed-cover watersheds with and without conservation practices, ranging in size from about 20 to nearly 5900 acres in the Blacklands of Texas. Hydrologic Bulletin No. 3[21] reports rates and amounts of runoff from 1938-1940 from a number of areas, 3.5 to 4 acres in size, and from four watersheds, ranging from 411 to nearly 3500 acres. These are the published data that have come to my attention. In the hydrologic bulletins[18, 19, 20, 21] no attempt whatsoever was made to analyze the data. Their purpose was to make the record available for such analyses as the user may care to make. The papers by Hoover and Hursh[16] and by Brater[17] were not intended to analyze the effects of land use or of conservation practices. They do, however, report some of the data.

By far the greatest part of the information obtained at great expenditures of funds and of effort remain unanalyzed and even unpublished. It is imperative in the public interest that the new information be analyzed and published. Such analyses will accomplish one of the following: (1) answer the important questions of effects of land use and conservation practices where the length of record is sufficient and the experimental setup adequate; (2) show that the experimental setup is adequate but that the length of record is too short to draw definite conclusions, or—and this is important—(3) show that the experimental setup is defective and that no matter how long the studies are continued no conclusive evidence will result.

The Subcommittee on Runoff could make a major contribution by helping to bring about the analyses and publication of all available information. It is a difficult task, but it must be undertaken. The Subcommittee hopes to get the full support of all members and non-members of the Society in this undertaking. To simplify the problem, this subject will be divided into two phases: (1) Effect on rates of runoff (floods) and (2) effect on total runoff (water supply). It is proposed to initiate two symposia, one dealing with each phase. The first step in this direction has already been taken. A special subcommittee of the Committee on Agricultural Hydrology (Subcommittee on Watershed Studies, L. L. Kelly, chairman) has been set up to complete a report on the location, scope, length of record, and other information pertaining to experimental watershed studies in the United States.

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This pumping plant for irrigating alfalfa land on the Otto B. Neely ranch in Maricopa County, Arizona, employs a three-stage Wintroath pump powered by a Caterpillar diesel engine

## RESEARCH NOTES

**(A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.)**

WHAT follows under this heading is the beginning of what it is hoped will be a regular feature of AGRICULTURAL ENGINEERING. Essentially it is a progress report on agricultural engineering research. It will undertake to keep readers informed on what is going on in research, that is, work that is being done and who is doing it. This month the work of the Divisions of Agricultural Engineering of the U. S. Department of Agriculture, including cooperative studies under way with the various states is featured. Future issues will carry similar reports from Washington and other federal stations. It is hoped that the agricultural engineering divisions of the state agricultural experiment stations will report progress on the engineering phases of research projects on which they are engaged, and private research agencies are also cordially invited to report their research activities and results.

* * * *

Development and testing under farm conditions of equipment for electric pasteurization of milk for use by the individual farmer is the object of a new project of the Division of Farm Electrification (USDA) being started in cooperation with the Connecticut Agricultural Experiment Station at Storrs. Engineer on the project will be W. A. Junnila, formerly with the Ohio Agricultural Experiment Station.

Plans for the new project were instigated almost a year ago, but the work could not be established at that time. When the new work was first planned, no individual pasteurizing equipment was available, though some work has since been done by manufacturers, and at the present time one pasteurizer is being offered. Some work on farm milk pasteurizers was done previous to the war by Nixon at the Cornell University Agricultural Experiment Station at Ithaca, N. Y., and by Burkhardt at the Maryland station. The Connecticut station has been active at various times in the development of pasteurization equipment and procedures.

The importance of the new project is indicated by recent figures on prevalence of undulant fever, particularly in rural areas. The figures, from the U. S. Public Health Service, show that the number of cases reported from rural areas increased from a total of 1,502 in 1932 to 4,759 in 1945. Of the cases reported, at least half are known to have resulted from drinking raw milk. Recent figures indicate that from 4 million to 12 million people in the United States have the brucellois germ which causes undulant fever and that some 40,000 annually are treated for the disease by the nation's doctors.

W. A. Junnila, engineer on the new project, is a native of Virginia, Minn., holds a bachelor's degree in electrical engineering from the University of Minnesota and a master's degree in agricultural engineering from the University of Missouri. Previous to his work with the Ohio station, he was at the State College of Washington at Pullman, doing research on various kinds of electrical equipment for the farm and later was in electrification work in private industry.

* * * *

More rapid and effective control of the European corn borer and those insects which destroy forests should result from recent improvements in airplane spraying equipment made in investigations by USDA agricultural engineers on pest and plant machinery control investigations at the Toledo, Ohio, laboratory. Developments during the past year include a new boom-type sprayer. With this device DDT in oil is applied at approximately 2 gal per acre, in a 35-ft swath at the rate of about 10 acres a minute. Used against corn borer in sweet corn, an average borer reduction in the stalks of 83.5 per cent and in the ears of 92.2 per cent was obtained. A similar unit used in a larger plane for forest insect control applied a gallon of this spray per acre in a 100-ft swath at the rate of 18 to 20 acres per minute.

* * * *

Engineering phases of agricultural problems in Alaska are being studied this winter by A. D. Edgar, USDA agricultural engineer, who is in charge of the potato storage investigations with headquarters at Ft. Collins, Colo. Edgar is one of a "task force" who went to the territory last summer under a commission by Congress to survey and report on Alaskan research needs.

The over-all engineering objectives of the studies are to gather first-hand information on the relation of United States and Canadian basic knowledge to Alaskan conditions; effects of ever-frozen subsoil; farm home and building construction; farm power and machinery needs; rural electrification and methods of securing adequate food and feed with the short production and transportation season and long-period storage.

Leaving the states in June, the party spent most of the summer on field surveys. Other members of the task force returned to the states early in the fall, but Mr. Edgar's assignment will keep him in Alaska until February. He is making observations of temperature, humidity, moisture condensation, and frost conditions in relation to engineering problems; and heating, water supply, and sewage problems in farm homes, dairies, poultry houses, and storage buildings as affected by the long cold winters.

Since going to Alaska, Mr. Edgar has made one trip back to the states, coming down by air to meet with Messrs. Barker, Wilson, and Tinsley of the British Potato Mission at Seattle, Wash., and at Ft. Collins in November. P. F. Gifford is in charge of the potato investigations at Ft. Collins during Mr. Edgar's absence. Edgar returned to his Alaska station at Palmer on December 4, at which time he reported winter had set in with temperatures ranging from 0 to 15 F and darkness settling at 4 p.m. with only six hours of daylight.

* * * *

Results of experiments in the flue curing of tobacco carried on during 1946 at Oxford, N. C., by agricultural engineers of the USDA and the North Carolina Agricultural Experiment Station show possibilities of big savings in fuel, time, and labor requirements through proper design of the curing barns, better types of furnaces, and use of electric controls and fans to circulate the heated air through the tobacco. Flue-cured tobacco is the main type used in cigarettes.

Using coal for heating during this past season, fuel requirements to cure out a barnful of tobacco have been reduced by as much as two-thirds through changes in ventilation and insulation of the walls. Although this season's results are only preliminary, they indicate the wide range in fuel costs that may result through poor design of the curing barns.

The series of tests is planned to include numerous types of fuels, furnace designs, and flue arrangements, use of electric controls, and forced-air circulation. Through the results of these experiments it is hoped to develop curing barns and methods that will eliminate much of the drudgery and long hours of furnace tending now associated with the handling of flue-cured tobacco.

An indication of the engineering problem involved is data gathered by Dr. O. A. Brown, engineer for the USDA on the project. He estimates that in curing each year's crop farmers handle more than 5 million tons of green tobacco at least eight times. After curing it is handled at least that many more times. Water evaporated from a year's crop of flue-cured tobacco during curing amounts to approximately 4½ millions tons. Arrangements have recently been made to expand the tobacco research work to include a curing project at the Georgia Agricultural Experiment Station.

* * * *

Beginning of the proposed cooperative research on animal housing between the USDA Division of Farm Buildings and Rural Housing and state agricultural experiment stations is still being delayed by material shortages, although one preliminary test run has been made with hogs at the California station at Davis. J. R. McCalmont is the USDA engineer in charge of the animal shelter research projects.

The preliminary experiment at Davis has served mainly to establish "landmarks" in the relationship of temperature to the comfort of hogs. Completed before the refrigerating and air-conditioning equipment had been placed in the desired operating condition, the test showed that a wet floor condition has a very important influence on the temperature that hogs can endure. Since the preliminary test was run, the apparatus has been completely reconditioned and the test rooms made ready for the experiments that will run through the complete attainable range of temperatures and humidity. C. A. Kelly is resident USDA engineer on the project.

At Columbia, Mo., the outer building of the new psychroenergetic laboratory has been completed and the two test rooms are ready for the interior finish and installation of equipment. The main shortages holding up completion of the laboratory are piping, sheet metal, and heat exchangers. The first work to be done at the Missouri station will be with dairy cows. Harold J. Thompson is the USDA resident engineer on the project.

Shortages also are holding up the start of the investigations on poultry housing at the Agricultural Research Center, Beltsville, Md. One of two calorimeters has been completed, except for control equipment, on which delivery has been delayed. J. R. Vincent is USDA resident engineer on the Beltsville experiments.

## New Federal and State Bulletins

"Safe Water for the Farm" by Harry L. Garver, senior agricultural engineer, division of farm buildings and rural housing, is the title of Farmers' Bulletin No. 1978 issued by U. S. Department of Agriculture.

"Electric Water Systems for Farm and Home" by M. G. Huber, extension agricultural engineer, is the title of Extension Bulletin 671 issued August, 1946, by Oregon State College.

"House Framing" by H. E. Wichers, professor of architecture is the title of Bulletin No. 50 issued in 1946 by the Kansas Engineering Experiment Station.

# NEWS SECTION

## Nominations for 1947 A.S.A.E. Officers

THE Nominating Committee of the American Society of Agricultural Engineers, consisting of A. J. Schwantes (chairman), I. P. Blauser, and R. C. Hay, have placed in nomination the following members of the Society for the various offices to be filled at the next annual election of officers:

*For President:*

George A. Rietz, manager, farm industry division, General Electric Company.

*For Councilor:*

J. G. Sutton, head, drainage section, engineering division, Soil Conservation Service, U. S. Department of Agriculture.

W. W. Weir, drainage engineer, division of soils, University of California.

*For Councilor:*

E. D. Anderson, agricultural engineer, agricultural extension bureau, Republic Steel Corporation.

B. T. Virtue, research and development engineer, The Torrington Company.

*For Nominating Committee:*

W. G. Kaiser, manager, farm bureau, Portland Cement Association.

I. D. Mayer, associate in agricultural engineering, Indiana Agricultural Experiment Station.

H. E. Pinches, director of research, Harry Ferguson, Inc.

J. B. Stere, agricultural engineer, agricultural service division, West Penn Power Company.

S. A. Witzel, professor of agricultural engineering, University of Wisconsin.

W. L. Zink, consulting engineer, Sears, Roebuck & Company.

The by-laws of the Society provide that by March 1st of each year the secretary of the Society shall mail each member, entitled to a vote, a ballot stating the names of the candidates for elective office to be filled at the next election.

## Fall Meeting Reflects Industrial Interest

REPRESENTATIVES of private enterprise in and serving agriculture constituted more than 70 per cent of the total of 575 men and women who attended the Fall Meeting and 3rd Barn Hay-Curing Conference of the American Society of Agricultural Engineers at Chicago, December 15 to 20. Abnormal teaching loads in the colleges accounted for the absence of a number of the faithful from that group.

Agricultural research under the Flannagan-Hope Act and forage crop handling were the outstanding special interests of the meeting. Well-balanced programs in farm electrification, farm power and machinery, and farm structures sustained the interest of their scheduled three days.

A capacity crowd attended the evening session on "Agricultural Research Under the Flannagan-Hope Act." Directors of state agricultural experiment stations and deans of agriculture and engineering colleges concerned, in addition to those on the program, were present in representative numbers, along with engineers from industry, the colleges, and the U. S. Department of Agriculture. Discussion pointed to substantial agreement that the anticipated research would necessarily involve the agricultural engineering field to a large extent and provide opportunity for cooperative work further relating the engineering approach to biological and economic problems of agriculture.

Following a wide range of reports of recent research and practical experience on hay drying, F. W. Duffee summarized the trend of progress and recommendations in the field with a number of specific points. These included continued use of field drying to the extent made feasible by weather and other operating conditions; minimum use of supplementary heat; and further attention to quality and cost factors in all methods and conditions of handling forage.

Current scarcity and high cost of farm labor, with the prospect that this situation may continue indefinitely, was reflected in all three technical division programs in attention to engineering means of expediting production results from the labor used.

In power and machinery sessions this was in the background of papers and discussions on precision planting equipment, pest control equipment, plow design, hydraulic controls, fuels, and hay-handling machinery.

In farm electrification it was the basis of attention to the costs and returns of farm electrical equipment, lighting, economics of farm freezers, ventilation, pasteurizers, and parlor milking.

The farm structures program gave it specific treatment in a session on farm work simplification, with additional touches in other papers on farm housing and animal shelters.

## A.S.A.E. Meetings Calendar

January 15 to 17 — Southeast Section, Buena Vista Hotel, Biloxi, Miss.

February 7 and 8 — Pacific Coast Section, Davis, Calif.

June 23 to 25—ANNUAL MEETING, Benjamin Franklin Hotel, Philadelphia.

December 15 to 17—FALL MEETING, Stevens Hotel, Chicago.

More detailed consideration of the papers and discussions is beyond the purpose of this account. The group present gave the over-all impression of being alert to the fact that agricultural engineers in this new postwar era face new problems, new challenges, and new opportunities.

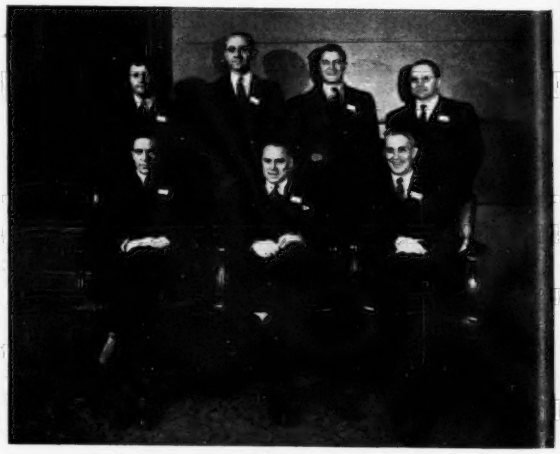
## Farm Structures Group Produces Regional Bulletin

THE first farm structures bulletin published as a result of the work of the North Central Regional Farm Structures Coordinating Committee was recently placed in distribution. It is "Beef Cattle Housing in the North Central Region of the United States," published as North Central Regional Publication No. 6 and South Dakota Agricultural Experiment Station Bulletin 382. It incorporates the recommendations agreed to in principle by the beef cattle production specialists and agricultural engineers in the region.

Preliminary information for the bulletin was assembled and put in rough draft form by the late Ralph L. Patty, who was a member of the committee. After his passing the manuscript was completed by Deane G. Carter, and final illustrations were prepared by Keith Hinchcliff.

Representatives from all 14 states in the region contributed to the conferences and discussions on the specific data to be included in the publication, and its final approval. Directors of the agricultural experiment stations in the states concerned and the U. S. Department of Agriculture approved the final manuscript before publication.

Printing was handled by the South Dakota station, and each participating state purchased the bulletin in quantity for distribution through its extension service. For purposes *(Continued on page 34)*



PACIFIC NORTHWEST SECTION GROUP

This group includes some of the newly elected officers of the A.S.A.E. Pacific Northwest Section. Seated, left to right: W. R. Friberg (secretary-treasurer), University of Idaho; June Roberts (chairman), State College of Washington; T. K. Dimmitt (vice-chairman), Puget Sound Power and Light Co. Standing, left to right: M. G. Huber (vice-chairman), Oregon State College; C. J. Hurd (member, nominating committee), Hurd Farm Electric Supply. G. H. Bliesner, Farragut College and Technical Institute, and Clyde Walker (extreme right), R. M. Wade Co., served, respectively, as temporary secretary and chairman prior to the Section's organization meeting. The Section has "drafted" Mr. Walker to serve as chairman of the local arrangements committee when the Section acts as host to A.S.A.E. at its annual meeting at Portland, Oregon, in June, 1948

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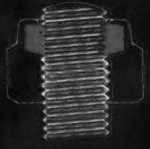

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of this coordination the North Central Region includes Arkansas, Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, and Wisconsin. Variations in construction required by variations in climate within the region are indicated in the text.

This bulletin represents a successful follow-up of the farm building plan service in coordination with agricultural engineering recommendations in the farm structures field, with a view to increasing the efficiency of extension work.

## Christian I. Gunness, A.S.A.E. Charter Member, Passes On

CHRISTIAN I. GUNNESS, professor and head of the division of engineering, head of the department of agricultural engineering, and a member of the agricultural experiment station staff at the Massachusetts State College, Amherst, passed on December 21, 1946.

Professor Gunness was born in Abercrombie, North Dakota, July 23, 1882. He attended North Dakota Agricultural College at Fargo and was awarded the degree of bachelor of science in mechanical engineering in June, 1907. He attained high scholastic honors and was elected to Phi Kappa Phi. His first employment was at his alma mater where he served as instructor and assistant professor of mechanical engineering, but centered most of his early teaching in farm power courses until 1912 when he became general manager of the Indiana School of Tractioneering as incorporated by the M. Rumely Company of LaPorte, Indiana. This school was the first of its kind organized for the purpose of giving instruction in the use and care of power-farming machinery.

In 1914 he was called to Massachusetts Agricultural College to organize a department of rural engineering. This has grown steadily under his guidance from a one-man start to a full-fledged department of agricultural engineering which now grants a professional degree. A few years ago additional tasks were added to his many duties when the College began developing other branches of engineering and entrusted these to his care.

He was a charter member of the American Society of Agricultural Engineers, a member of the American Society of Engineering Education, and a member of Sigma Xi. He served as deacon and trustee of the First Congregational Church of Amherst for many years and was active on several town committees.

His primary interests were in research where he pioneered in food and fruit storage, refrigeration, cranberry bog low-lift pumps, and more recently in cranberry storage and hay drying.

Professor Gunness was a quiet, unassuming man, prone to keep his fine work free from glamour. Never did he lose his love for any problem in agricultural engineering.

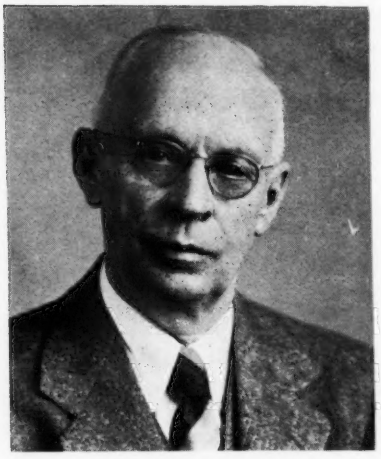
His widow, Elizabeth (Rice), one son, Robert C., of Flossmoor, Illinois, and one daughter, Marion E., of Elizabeth, New Jersey, survive him.

## S. H. McCrory Honored at Dinner

EMPLOYEES of the former USDA bureau of agricultural engineering, many of whom are still employed in the present divisions of agricultural engineering and the irrigation and drainage divisions of the Soil Conservation Service, honored S. H. McCrory, former chief of the bureau, with a dinner, December 6, at the Log Cabin Cafeteria at the Agricultural Research Center, Beltsville, Md. Mr. McCrory retired from the federal service on November 30.

The program for the occasion was developed to point up the highlights in the career of Mr. McCrory as an agricultural engineer. Born at Iowa City, Iowa, in 1879, he was graduated with a bachelor's degree in civil engineering from the University of Iowa in that city. After a few years in private engineering practice at Sioux City, Iowa, he entered the employ of the U. S. Department of Agriculture as a drainage engineer in the Office of Experiment Stations on January 1, 1907. When the Division of Agricultural Engineering was established in the Department in 1921, Mr. McCrory became its chief, and ten years later when the work was given bureau status, he was made chief of the bureau.

During his career as an engineer, Mr. McCrory was selected as the first recipient of the John Deere Medal awarded by the American Society of Agricultural Engineers. He was responsible for carrying on or instigating many important investigations, particularly with respect to drainage and irrigation work. Among those listed in AGRICULTURAL ENGINEERING at the time he received the John Deere award were studies of the value of the roughness coefficient in Kutter's formula for flow in open channels, inauguration of snow studies on western watersheds as a means of predicting water supplies for irrigation and power, development of methods of survey and design particularly suited to swamplands and their drainage, and studies in the promotion of underground storage of water resources. While chief of the Bureau of Agricultural Engineering, he was also responsible, in a large part, for creation of the first soil erosion station at Guthrie, Okla., in 1929, of the USDA Tillage Machinery Laboratory at Auburn, Ala., and for inauguration of agricultural engineering extension work by the Department of Agriculture. Since 1942, Mr. McCrory has been director of the hemp division of the Commodity Credit Corporation.



CHRISTIAN I. GUNNESS
1882 - 1946

Master of ceremonies at the dinner given for Mr. McCrory was Geo. R. Boyd, present head of the division of mechanical processing of farm products and assistant chief of the former bureau of agricultural engineering. A. W. Turner, present chief of the agricultural engineering divisions of the Department, spoke briefly concerning the foundation for agricultural engineering laid under Mr. McCrory's direction and pledged the present divisions to carry on and build up the work as rapidly as conditions permit.

A feature of the program was a humorous playlet, spotlighting events in Mr. Crory's career. Entitled "Memoirs of a Marijuana Merchant, or Pipe Dreams of a Great Engineer", it was climaxed with the award of a huge synthetic medal "for development of a plan to lay drainage tile throughout the Great Plains, then pump the Atlantic Ocean up the Mississippi River and its tributaries and out through this drainage system to subirrigate all of this vast area in the central part of the United States."

## Texas A. & M. Takes Progressive Step

THE A. & M. College of Texas has taken a most progressive step in a plan to reorganize the agricultural division of the College under an arrangement to coordinate resident teaching, research, and extension activities on a subject-matter basis. The new plan provides for nine subject-matter departments: agronomy, agricultural economics and rural sociology, agricultural engineering, dairy husbandry, landscape art, plant physiology and pathology, poultry husbandry, range and forestry, and horticulture.

F. R. Jones will become head of the new expanded agricultural engineering department.

## Personals of A.S.A.E. Members

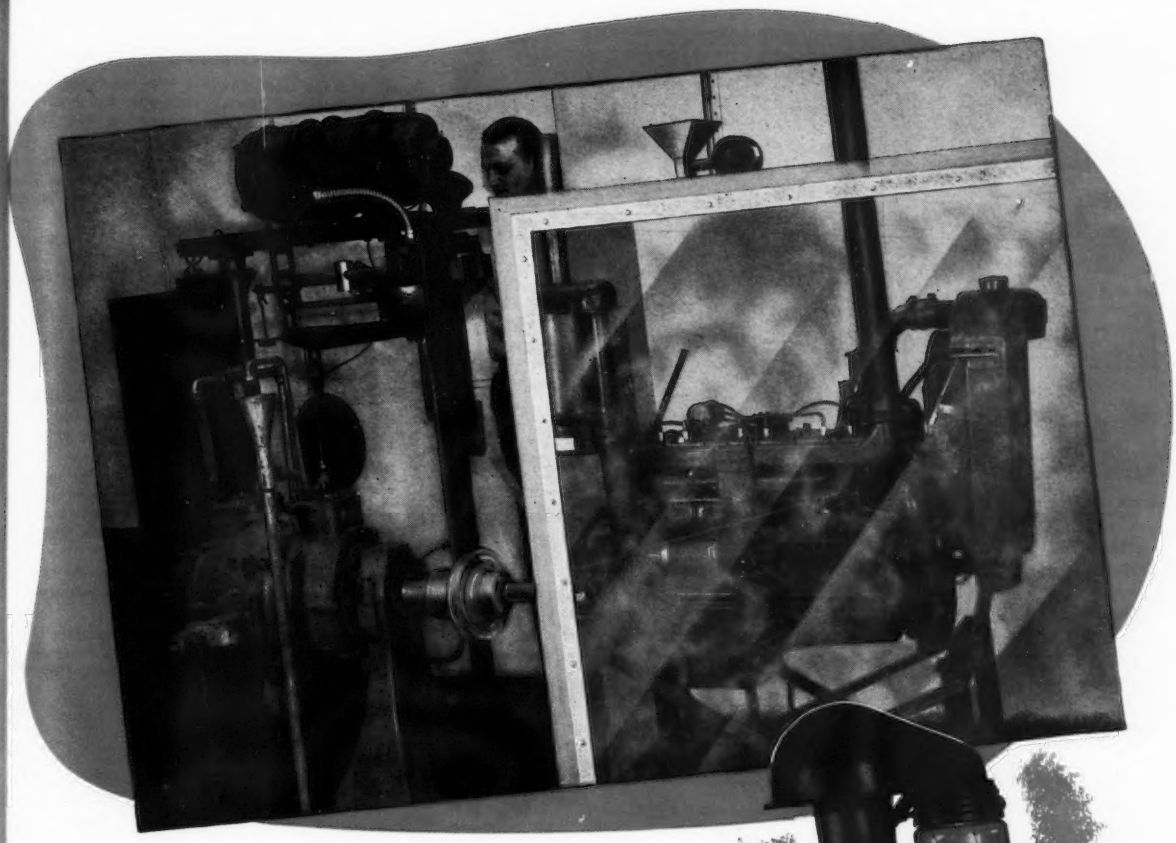
*Gustav H. Bliesner* has resigned as assistant extension agricultural engineer at the State College of Washington, to accept appointment as assistant professor of physical sciences at the Farragut College and Technical Institute, Farragut, Idaho. The institute has recently been acquired from the U. S. Navy and has training facilities for 11,000 students. Mr. Bliesner's work will be in the nature of a beginning of the engineering curriculum.

*E. N. Humphrey* recently returned from 26 months service as military governor in Bavaria, Germany, where he served with the rank of major, and is now deputy reclamation engineer for the State of Idaho with headquarters at Boise.

*Harold A. Kramer* recently resigned as research associate in agricultural engineering at the Louisiana Agricultural Experiment Station, to become associate agricultural engineer with the agricultural engineering divisions (BPISAE), U. S. Department of Agriculture. He will be located at the U. S. Sugar Plant Field Station at Houma, La.

*George Krieger,* chairman, agricultural development committee, American Petroleum Institute, presided at an agricultural session sponsored by his committee as a feature of the 26th annual meeting of A.P.I., held in Chicago last month.

*(Personals continued on page 36)*



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## Personals of A.S.A.E. Members

*(Continued from page 34)*

*Henry N. Luebcke,* who for some time has been employed by the Soil Conservation Service at Grand Haven, Michigan, has been promoted to associate agricultural engineer and assigned to duty by the Service at Wapoteneta, Ohio.

*R. J. McCall* recently resigned as assistant professor of agricultural engineering extension at Pennsylvania State College, to become associated with the Howard S. Sterner Company, Columbus, Ohio, in the capacity of agricultural engineer.

*John F. Mitchell,* who has been serving as chemical engineer for the Tennessee Copper Company at Copper Hill, is now employed in a similar position by the Celanese Corporation of America at Rome, Georgia.

*Charles B. Peak,* who served as a lieutenant with the U. S. Army Engineers during the war, has returned to civilian life and is now employed as design engineer on orchard and row crop sprayers with the Hardie Manufacturing Co., Hudson, Mich.

*John W. Propst, Jr.,* who served as a captain in the Engineer Corps of the U. S. Army during the war, is now employed as assistant agricultural engineer in the extension division of the agricultural engineering department of Virginia Polytechnic Institute.

*John A. Schaller,* who for several years has headed up the research section of the agricultural engineering development division of the Tennessee Valley Authority, has resigned to accept the position of advertising manager of Rilco Laminated Products, Inc., First National Bank Bldg., St. Paul 1, Minn.

*C. Edward Williams* is now employed as an engineer by the Wilson Cabinet Co., Smyrna, Del., manufacturers of commercial refrigeration equipment.

*Francis D. Yung,* research engineer in rural electrification, University of Nebraska, is author of Agricultural Engineering Progress Report No. 15, entitled "An Automatically Heated Stock Watering Trough," recently issued by that institution.

## Necrology

WAYNE H. CARVER, editor, "Locker Operator", national magazine for the frozen food locker plant industry, passed on in Des Moines, Iowa, on November 25.

Mr. Carver was widely known in the locker plant and refrigeration engineering industries. He was one of the founders of the National Frozen Food Locker Association, and was a frequent speaker at Association and refrigeration engineering meetings throughout the United States and Canada. As part owner of Locker Publications Co., Mr. Carver began editing "Locker Operator" with its first issue in August, 1939, and later helped in establishing the annual publication "Locker Industry Guide Book", of which he was also editor. He was part owner of locker plants in Des Moines, Toledo, Tama, Chelsea, and Garwin, Iowa.

Mr. Carver was a graduate of Drake University, and he was a member of the Des Moines Consistory, of the American Society of Agricultural Engineers, and of the American Society of Refrigerating Engineers. He was particularly active as chairman of the locker plant standards committee of the latter organization. He is survived by Mrs. Carver, a daughter, and his mother.

## Applicants for Membership

**The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.**

*William M. Anderson,* agricultural engineer, Tennessee Valley Authority, 605 AB, Knoxville, Tenn.

*Norman F. Andrews,* engineer on corn pickers, John Deere Harvester Works, East Moline, Ill.

*Milton F. Boneberg,* instructor, Meridian Vocational School, Meridian, Miss. (Mail) 2513 36th St.

*Albert L. Brodie,* technologist, The Texas Co., 332 S. Michigan Ave., Chicago 4, Ill.

*Pablo A. Carreno,* agricultural engineer and sugar chemistry expert, Central Convadonga. (Mail) No. 41 3rd Ave., Miramar Marianao, Havana, Cuba.

*Wendell C. Dean,* Frank J. Zink Associates, 141 W. Jackson Blvd., Chicago 4, Ill.

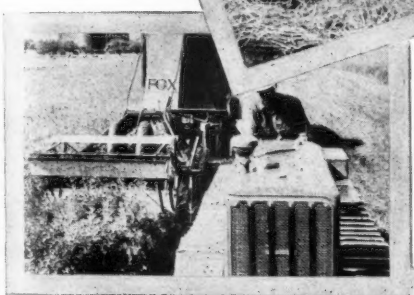
*A. N. Duckham,* agricultural attache, British Embassy, Washington, D. C.

*Augustus C. Durdin, III,* chief engineer, pump div., Geo. D. Roper Corp., Rockford, Ill. (Mail) 1734 Camp Ave.

*Paul E. Ellingson,* specification engineer, Veterans Administration. (Mail) 3452 Emerson Ave., S., Minneapolis, Minn.

*(Continued on page 38)*

# The FOX will give you all "3"



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R. G. Krueger
Secretary

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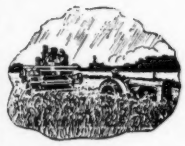

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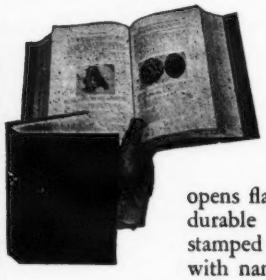

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## Applicants for Membership

*(Continued from page 36)*

*Jack B. Eshelman,* sales promotion, John W. Eshelman & Sons, 244 N. Queen St., Lancaster, Pa.

*Herbert J. Fleming,* advertising copywriter, J. I. Case Co., 700 State St., Racine, Wis.

*Earl D. Flood,* president, The Flood Co., 6217 Carnegie Ave., Cleveland 3, Ohio.

*J. Harold Forby,* division manager of rural sales, Public Service Company of Northern Illinois. (Mail) Box 278, Glencoe, Ill.

*Maynard S. Grunder,* agronomist, Western Washington Experiment Station, Puyallup,, Wash.

*Herbert E. Hentschel,* 1244 Terrace St., Muskegon, Mich.

*John W. Jackson,* in charge farm machinery section, Elastic Stop Nut Corp., Union, N. J.

*Fred N. Johnson,* manager, irrigation dept., Armco Drainage & Metal Products, Inc., Portland, Ore. (Mail) 5316 S. E. 50th Ave., Portland 6.

*Otto E. Johnson,* junior engineer, Canton Works, International Harvester Co., Canton, Ill.

*Stanley E. Jones,* agriculturist, Bureau of Reclamation, USDI. (Mail) 2510 M St., Bakersfield, Calif.

*Hans C. Kjorven,* in charge of irrigation, Dominion Experimental Station, Swift Current, Sask., Canada.

*Bob Krehbiel,* chief project engineer, Lindeman Power Equipment Co., 1011 So. Third St., Yakima, Wash.

*Frank G. Mackaness,* agricultural consultant, Portland General Electric Co., 621 S. W. Alder St., Portland 5, Ore.

*Lloyd M. Miller,* rural service engineer, Appalachian Electric Power Co., 523 Main St., Lynchburg, Va.

*Reading Overstreet,* factory field representative, Bean-Cutler Div., Food Machinery Corp., San Jose, Calif. (Mail) 1654 "The Alameda".

*Glenn A. Patterson,* vice-president, Sta-Rite Products, Inc., Delavan, Wis.

*Wendell W. Prater,* assistant county agent (agricultural engineer), Kittitas County Extension Service, 305 N. Main St., Ellensburg, Wash.

*Harold J. Rollinson,* rural representative, Pennsylvania Power Co., 100 W. State St., Sharon, Pa.

*Millard Shaw,* agricultural engineer, Soil Conservation Service, USDA. (Mail) R. R. No. 4, Box 641, Victoria, Tex.

*Ernest Shorrock,* sales engineer, General Electric Co., 140 Federal St., Boston, Mass.

*George O. Snead,* production representative, General Implement Corp., 1532 Candler Bldg., Atlanta, Ga.

*Milford D. Stewart,* chief engineer South Bend plant, The Oliver Corp. (Mail) 1130 E. South St., South Bend 15, Ind.

*Frank F. Swick,* manager, Pennsylvania Farm Bureau Cooperative Assn., 3607 Derry St., Harrisburg, Pa.

*Roger M. Vose,* farm engineer, Starline, Inc., Harvard, Ill. (Mail) 301 Church St.

*Dwight F. Warner,* instructor in agricultural engineering, Ohio State University, Columbus 10, Ohio.

TRANSFER OF GRADE

*Dale K. Bee,* rural representative, Cincinnati Gas & Electric Co. (Mail) 306 N. Main St., Bethel, Ohio. (Associate to Member)

*Santiago R. Cruz,* general manager, Paulino Cruz, Inc., Manila, P. I. (Mail) 1432 P. Guevara, S. C. (Junior Member to Member)

*F. D. Dale,* agricultural engineer and rancher, Coldwater, Kans. (Junior Member to Member)

*Julian M. Fore,* agricultural engineer, Tennessee Valley Authority, Knoxville, Tenn. (Junior Member to Member)

*Harold E. Gray,* research assistant in agricultural engineering, Cornell University. (Mail) North Stonington, Conn. (Junior Member to Member)

*Norton C. Ives,* chief, agricultural engineering dept., Inter-American Institute of Agricultural Sciences, Box F, Turrialba, Costa Rica. (Junior Member to Member)

*Everett C. Kneece,* assistant branch manager, International Harvester Export Co. (Mail) Caixa Postal 180-B, Sao Paulo, Brazil. (Junior Member to Member)

*John W. Propst,* Jr., assistant agricultural extension engineer, Virginia Polytechnic Institute, Blacksburg, Va. (Junior Member to Member)

*A. H. Scrimshaw,* Jr., plant clearance inspector, War Assets Corp. (Mail) 1208 Victoria Ave., Saskatoon, Sask., Canada. (Junior Member to Member)

*Arnold B. Skromme,* field engineer, Auto Specialties Mfg. Co., St. Joseph, Mich. (Junior Member to Member)

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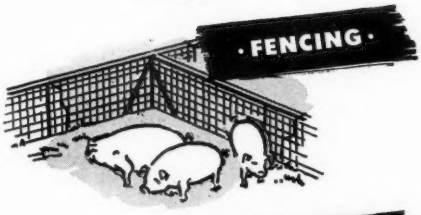


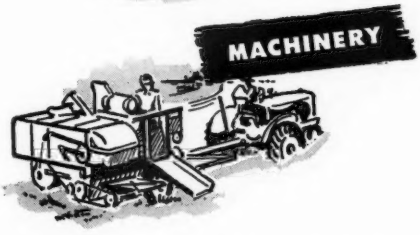


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RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.


## *Personnel Service Bulletin*

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

Attention is invited to the desirability of checking on the housing situation when considering a new location.

POSITIONS OPEN: MAY—O-499, 500, 502, 503. JUNE—O-506. AUGUST—O-510, 511. SEPTEMBER—O-516, 520, 521. NOVEMBER—O-523. DECEMBER—O-526, 527, 531, 532, 533, 534.

POSITIONS WANTED: FEBRUARY—W-207, 210, 254. APRIL—W-232, 237, 240, 258, 262, 276, 292. MAY—W-309, 312. JUNE—W-316, 320, 322. JULY—W-327. SEPTEMBER—W-336, 337, 341. OCTOBER—W-348, 352, 353. NOVEMBER—W-354, 355, 356, 358, 359. DECEMBER—W-361, 362, 363, 364, 365, 366, 367.

### POSITIONS OPEN

MECHANICAL ENGINEER for design work on centrifugal and ejector pumps, for established manufacturer in Midwest. BS deg in mechanical engineering, with field, factory, and design experience. Must be dependable and show initiative. Excellent opportunity for advancement. Age, under 40. Salary open. O-535

AGRICULTURAL ENGINEER (instructor rank) for teaching and research in farm power and machinery in an East Coast land grant college. BS deg in agricultural or mechanical engineering. MS deg and some teaching or research experience desirable. Usual personal qualifications for college work. Arrangement can be made for graduate study. Opportunity to advance to assistant professor in three years. Salary $2640 min. O-536

### POSITIONS WANTED

AGRICULTURAL ENGINEERING STUDENT desires summer work in power and machinery or rural electric field, with a view to permanent employment after graduation. BSA deg, with major in agricultural mechanics, expected in 1947; and BE deg, with major in agricultural engineering, expected in 1948, University of Saskatchewan. Two years as student instructor in motors. Farm background, with one summer on Dominion Experimental Farm on cereal variety testing, and one summer with Dominion Forestry Branch on shelterbelt planting. Enlisted and commissioned war service. No physical defects. Available May to September inclusive, 1947 and 1948. Single. Age 23. Salary open. W-368

AGRICULTURAL ENGINEER desires sales work in power and machinery field. BS deg in agriculture expected January 1947 University of Wisconsin. Farm background. Enlisted and commissioned war service in Marine Corps. No physical defects. Available January 20. Married. Age 25. Salary open. W-369

AGRICULTURAL ENGINEER desires experimental or maintenance work in engineering department of farm equipment manufacturer or utility company. BS deg in agricultural engineering, Pennsylvania State College, 1943. Truck farm background; three summers employment on dairy farms; Navy commissioned war service; six months extension work in agricultural engineering. No physical defects. Available April 1. Married. Salary $2550. W-370